TRACK TECHNIQUE

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Foreward

This is the first issue of a new journal devoted to the technique of track and field athletics. Our aim is to collect and publish the best available information on proficiency in all the events.

We fully intend to help round out the professional education of the finest coaches, for they are the ones most likely to study the contents of "Track Technique". We also hope to provide basic knowledge for other coaches, and so certain articles will be more fundamental and less technical. And, of course, we expect "Track Technique" to be studied, in part, by serious athletes. Last, we believe many of the more avid track fans will read "Track Technique" both for enjoyment and for the greater pleasure obtained from knowing more about our sport.

We have had this project in mind for several years, but it was only recently that we found the proper man to do the tremendous job of editing. We needed a man with great knowledge (both theoretical and practical), with wide contacts in the track world, and with the burning energy and drive necessary to a project of this scope. We found our man in Fred Wilt, whose experience as an athlete and as an unpaid coach, plus his masters degree in physiology and his unceasing thirst for knowledge make him fully qualified for the job.

We hope to publish "Track Technique" quarterly, but we cannot commit ourselves until we are sure how many of you want it to continue. We invite your comments, your criticism, your suggestions, and your subscriptions.

We also invite contributions. Those of you who have something to say will find here an outlet. Suggestions or queries concerning specific articles should be directed to Fred Wilt (2540 Edgelea Drive, Lafayette, Indiana). He will tell you if your idea is too similar to another already "in the works", not of sufficient interest, or something he wants to see in full. Editor Wilt is, at present, almost inundated by the flood of articles from Europe, in many languages. He is crying for enthusiasts to help in translating from German, Spanish, Russian, Yugoslavian, Polish, and French.

Every article in "Track Technique" cannot possibly please every reader, but a preview reading of the articles in this issue makes us confident that a large percentage of the serious people of our track world will become at least mildly excited about "Track Technique". We believe enough excitement can be generated to make this a truly worthwhile contribution to the sport we love.

THE PUBLISHERS —

Bert and Cordner Nelson

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Speed or Endurance Training?

by Dr. Ernst van Aaken
(Translated by Dr. Nolan Fowler)

Since the year 1928 when I watched Paavo Nurmi at the Amsterdam Olympics warm up for two hours before a race, it has been clear to me that modern civilized man is not lacking in speed but in endurance. This one thing, then, is necessary for all runners -- to acquire the quality of endurance at the very outset and then to fight daily to keep it. In my opinion, one can't start this endurance training early enough in life, because, according to my own observations, it is just children who are born long distance runners. What children do badly are such exertions as bicycling for speed, weightlifting and sprinting, particularly in excess of 100 meters. On the other hand, any healthy boy or girl is able to run as much as three miles at a moderate pace. The play of children is nothing more than a long distance run because in a couple of hours of play they cover many kilometers with several hundred pauses.

The play of children is the primal form of interval training. I arrived at this conclusion after taking into consideration the training methods of the top German runners such as Herbert Schade, Paul Schmidt, Friedel Stracke, Werner Lueg, and many others. I also train my own runner's club according to these principles. As the result of this training, the boy and girl athletes of my club, which by the way is located in a village of 7,000 inhabitants, had the best average times at 600, 1500, and 3000 meters of any representatives in West Germany. One of my useful runners, Edgar Forche, became the German Youth Champion in the 1,500 meters run with a time of 3:59.9. None of my good runners has any talent for the sport, but through much training which was only of the endurance variety, they have become excellent performers.

Edgar Forche, for example, ran daily in the forest last winter after school. His workout consisted of 5 x 3,000 meters in a time of between 11 and 13 minutes. Very seldom did he do any sprinting. Later, though, he was so fast that he was able to do 400 meters in about 0:49.5. When our best long distance runner, Roland Watschke, (who also had no ability) started with me he did the 5,000 meters in about 18 minutes and the 10,000 in around 40 minutes. At the outset he stuck to speedwork, much to my regret. He frequently did 10 x 200 meters in 29-30 seconds and did not better himself at all. It was only when he finally took my advice and changed his training that any improvement was made. He now ran in his workouts 20 x 1,000 meters at the slow pace of 3:10-3:20 with walking intervals of 200 meters, or he would do 30 x 600 meters in 1:45-1:50. At no time did he do any sprinting. As a result, he quickly improved his 5,000 meter time in one year from 16:23 to 15:18 and his 10,000 meter time from 33:48 to 31:57. His training distances now became longer, for the most part, so that at a workout he would do 5 x 3,000 meters, plus 40 x 400 meters the latter at 70-75.

As a consequence, Watschke improved in the next year from 15:18 to 14:46 in the 5,000 -- and then in the last year to 14:14.6! At the 3,000 meter distance he attained 8:12, although he has not actually done any sprint-training in the last year. Frequently, though, he has run sets of 30 x 100 meters at 14 seconds each with his clubmates, Mullęr-Wesel. His basic training, however, consisted always of daily long distance runs totalling about 20 kilometers.

The present training of Watschke who has again joined my club will have somewhat the following look: In the mornings, starting at 5:45, he does 15 minutes of exercise (calisthenics), followed immediately by an easy warmup of 10-12 kilometers. His occupation busies him from 8 a.m. until 5 in the evening. From 5:30 until 8:30 p.m. he usually does the following: 5 x 3,000 meters in the forest at a pace of between 10 and 12 minutes with a three minutes walking interval between each. Then he does 20 x 500 meters with a pickup in the pace from the 300 meters mark. Each of these is done in about 1:30. Next he does 2 x 200 meters in around 29 seconds, and finishes with 3 kilometers of warming down running. With this training schedule, which amounts to 35-40 kilometers per day, we hope to bring Watschke under 14 minutes for the 5,000 and to get him down to

29:30 for the 10,000.

I have shared similar training plans with many German runners, and I have always observed that when the athlete's performance remains at a standstill the cause was due to an accumulation of very fast 200 meter runs, done one after another. But as soon as the runner switched to the longer training distances, done at a slower, softer pace, an improvement was started at once.

One could give hundreds of examples from the history of athletics to substantiate this observation. May I remind you of the example of the Swedish runner, Nystrom, who in 1952 turned to the marathon because he was not able to reach the qualification standard set for the 5,000 meters. This marathon training, however, improved him so much in the same year that after the Helsinki Olympics the 37-year old runner beat Herbert Schade here in Dusseldorf over the 10,000 meters in the new Swedish record time of 29:23.8. Through his marathon training he had become faster at all the shorter distances. Let's take another example. Our great German middle distance runner of an earlier day, Dr. Otto Peltzer, was very fast over the 100 meters distance, attaining a time of 0:10.8. He set a world record of 1:51.6 at 800 meters in 1926. I have put this question many times to those coaches who insist that speed achievement must come first in the development of a runner: Why was Peltzer only able to run 1:51.6, and why do the decathlon men -- those who are able to run the 100 meters under 11 seconds -- run such terrible races at 1,500 meters, if sprinting ability was the most important ingredient?

To ask the question is to answer it. These distance runners lacked the most important factor -- endurance. There, for instance, was Werner Lueg who was never able to run the 100 meters faster than 0:11.7, and who, as a matter of fact, found even the 1,500 meters too short, but who in an athletic tour of Japan was able to run the 800 meters in 1:49.7 because at this time he was in the condition to run 3,000 meters under eight minutes. There are hundreds of such examples in the athletic history of the last 30 years.

The performances of the Polish runners in the last year proves that endurance training, physical condition, and a light bodily weight are prerequisites for good performances at distances over 800 meters. The research of Professor Reindell of Freiburg (Germany) plus the results of my own investigations prove that the best long distance runners are those who have a great heart volume, a slight body-weight, and have strong and, if possible, long legs. The normal adult man has a heart volume of about 600 cubic centimeters. Sprinters, however, have for the most part also only 600 c.c. Middle distance runners have a heart volume of 750-900 c.c., the long distance men have volumes of 900-1200 c.c., and many professional bicycle racers have heart volumes in excess of 1200 c.c.

If one divides the heart volume, expressed in cubic centimeters, by the body weight, stated in kilograms, the result is a quotient which I have termed the "endurance quotient" in German literature. In medical literature this heart quotient may be regarded as the yardstick for determining whether the heart is too large or too small in proportion to the body weight. If the quotient is less than eight, then the heart is too small; if it is larger than 11, then, in the opinion of medical science, the heart is too large.

I myself have found that the best long distance runners of the world show a quotient of 17, while very good -- not the top -- distance runners have at the very least a quotient between 12 and 14. The Russian, Popov, appears to have the record with a body weight of 54 kilos and a heart volume of 1200 c.c. which gives a quotient of around 22. In 1958, Paul Schmidt had, according to an examination which I gave him, a heart volume of 873 c.c. and a weight of 60 kilos which results in an endurance quotient of 14.5. The astonishing thing, though, is that children of 5-14 years of age whom I examined had much higher endurance quotients, on the average, than untrained adults. The reason for this is that in relation to their body weight children have a greater heart capacity, expecially if they are lively children.

This past summer, I had a student in my girls' group who was 12 years old, 4'.6$\frac{3}{4}$" tall, and weighed 32 kilos, who, without any special training, was able to accomplish the 600 meters in 2:01.5. This child had a heart capacity of 435 c.c. which gave her a resulting endurance quotient of13.6, a figure which only a very good long distance runner could show. In this figure (quotient) one can detect the relationship between a light body weight and the large beating capacity of the heart, or, to use a technical expression derived from the automobile, she had a strong "heart

motor" and a light car-body.

The youngest participant in these investigations (researches) was five years old; he ran the 50 meters in 13.1 and the 600 meters in 3:12.0. Sleeping, his pulse rate was 96; in play it was 110-120; and after a 600 meter run his pulse recovered itself in each 10 second interval as the following pulse counts show: 180, 162, 138, 120, 96, 102, 102, 96, 102, 114, 96. This quick fall of the pulse beat from 180 to 96 inside of 50 seconds is such as only some marathon runners could show. That this was no isolated indicent, can be demonstrated in the fact that from 16 other children, all of whom were under six years, I ascertained the same values. The average heart volume of these little 600 meter runners was 278 c.c., their body weight was 19 kilos; consequently, their endurance quotient was 14.6.

It turns out, as a result of these investigations, that the performances of these smaller children was conditioned less by the increase of heartbeat frequency than by the great heartpumping capacity which operated during their work, just like one finds in a trained runner. The preponderant majority of the sports medicine fraternity maintains that the child attains (reaches) his performances through increases of frequency of heartbeats and for that reason show less endurance, and therefore doubts that he should be expected to practice endurance training. The sports medicine people have found out, though, that children between 10 and 12 years old have a very high oxygen intake capacity. My own experience is this, that the child and the teenager of school age endures a constant but not too strenuous a task just as well as the grownup. Children and students, however, can't take very well explosive muscle functions, such as the sprints, and consequently react to them with very strong increases in the frequency of the heart beat. For example, a boy or a girl never runs 100 meters in maximal tempo but becomes slower and slower. If the speed, however, is only slightly lowered and kept at a constant rate it can be endured for a much longer time than is the case with untrained adolescents. The high increases in the frequency of the heart beat which have always been attributed to a child or student are valid only for the sprint or maximal achievements, and one can take it as established that a child or an adolescent is able to take this uneconomical work in the anaerobic phase (which means without oxygen) only very poorly. It wouldn't be the correct thing to send children during running training and competition only over short distances, but it is known to everyone that most healthy and agile children are able to play and run for hours on end without particular fatigue. Even, master runners like Paul Schmidt don't show better pulse after the competition than those children do. At the examination at Waldniel, Paul Schmidt ran 1000 meters in his training clothes during winter at half emphasis (speed) on a highway in 2:49 and showed afterwards the following pulse beat: 180, 168, 144, 150, 126, 132, 120, 120, 120, 114, 114, 108, 114, 108, 114, 108, 114, 102. The sum total of pulse beats in five minutes amounted with Paul Schmidt after a run of 1000 meters to 594, while with a five-year-old one after a 600 meter run it amounted to 576. Similar numbers were ascertained with over 80 children between five and 14 years of age. Paul Schmidt had a relative pulse at rest (lying down) of about 60 before the run and after 20 minutes warmup one of 108. The child as mentioned above had an absolute rest pulse (while sleeping) of 96. At play it showed 114 and only 50 seconds after the run the pulse frequency fell to 96 (that means below the pulse at play). On the other hand, Schmidt 50 seconds after his run had 126 beats per minute which was 18 more than the beat of his warmup.

Only Herbert Schade showed similar pulse relations as the child long distance runners. One can agree with Professor Reindell when he assumes that a child has a greater capacity for recuperation. Out of 107 children, aged 12 and 14, whom Reindell and his colleagues examined, the children matched the achievements of the grownups, and the high pulse frequencies registered at those trials is to be explained by the maximal strain in the Anaerobic Phase. According to my training observations, the child during continued (or constant) endeavor is in steady-state superior to the adult. Children and adolescents up to the age of puberty run longer stretches instinctively in steady-state, and only the adolescents in the stage of puberty storms on and squanders his strength, showing a very unstable function in his circulation. The researches of Dr. Hollman at the Sport College in Cologne which shows a smaller rise of lactic acid after exercise by the juveniles can be traced to the fact that the juvenile doesn't contract any debts in oxygen and either avoids maximal strain or tires out quickly. But the child doesn't tire at play or in the long stretch

runs when he performs at the appropriate constant speed, that means, in steady-state, and he runs the 400 meters in a way that there is no oxygen debt whatsoever. Applying the Waldniel method of training, we maintain that endurance is the most important factor in long distance running and that methods which besides endurance stress too much muscular development, such as weight lifting, gymnastics, and sprinting (which are used percentagewise less) do not increase the capillaries of the muscles which are so important for the middle and long distance runner, but only increases the strength which is wholesome only for short stretches and is only a hindrance in long ones.

The true all-around runners are slim and graceful and still enormously speedy (Zimny, Pirie, Iharos, and some other ones), and these runners are towards the end of a run -- in the second half of the race -- always speedier than their strong muscled competitors. Thus, Iharos while making his 13:40.6 5,000 world record ran the last 1000 meters in 2:33.6, a speed which many a muscular middle distance runner can't match on account of the over-development of his muscles. At the marathon run the shortest and lightest one with the greatest heart pumping capacity, namely Popov, USSR, was also the speediest. The strong and muscular sprinter has received from nature a one-sided gift, namely, speed alone. But under different circumstances this very speed hinders the development of endurance and that is paradoxically the reason why the speediest 100 meter runner is hardly ever the speediest whenever the distance goes over 400 meters.

As far as an examination of the blood of the runners is concerned, there are so many differences among the trained runners that several thousand more chemical analyses will have to be done before coming to solid conclusions. This much can be taken as established from the researches at Waldniel: The uric acid increases after strenuous runs but more so after short than after long stretches. The creatinine increases in the urine with the sprinters but decreases with long distance runners which means that the latter ones are more economical with their valuable substance (creatine phosphoric acid).

As for the diet of a long distance runner, I would like to say, in short, that it is necessary above all to eat little, but such food as is eaten should be of high nutritive value. Counting as average the diet of normal people, we find that they consume daily 100 grams fats, 80 grams of proteins, and 500 grams of carbohydrates. The athlete, on the other hand, ought to consume daily 800 grams of carbohydrates, 50 grams fat, and 200 grams of protein. The protein, being of high nutritive value, is most essential, and it cannot be replaced by plant proteins. It is taken best in the form of milk protein, egg protein, and lean meat. Slender runners who lose weight easily may drink beer, but otherwise alcohol can in no way be recommended. Additionally, vitamin tablets containing all the vitamins (particularly B and C) and which are soluble in water, are to be recommended. The activity of gymnastics has its place only to correct the weaknesses of the body, and to strengthen the leg and abdomen muscles. The sprinter needs special gymnastics, and only the runner up to 400 meters is able to -- and should incorporate weightlifting and strength exercises into his training. A sprinter should run five kilos a day in forests; a middle distance man up to 15 kilos, and a 10,000 meter runner should do forest running up to 30 kilos. A marathon runner should on nice days in the spring even touch (reach) 80 kilos. Only the athlete who runs daily, lives modestly, without touching his reserves, and who eats little but well will ever become a good runner.

Stress and Training

By Fred Wilt

Dr. Hans Selye pointed out during a lecture to a group of physicians a few years ago that anything that is too much is stress. It is impossible to live without stress. Stress results even when the heart beats. Stress may be regarded as a rate of wear and tear. Selye has indicated that the body has a finite quantity (not an infinite, non-specific amount) of adaptation energy which it can transfer from one activity to another. Prolonged or chronic exposure of the body to one

(continued on page 11)

The Blood Test as a Guide to Training

by Major Kalevi Rompotti

Endurance of high order, unyielding physical and mental tenacity, and "guts" are the secrets of success for the middle and long distance runner. But upon what does this psycho-physical endurance ultimately depend?

Endurance is partly a question of nature, partly a question of skill and ability to relax, and also a question of nutrition. Particularly from a physiological standpoint, endurance is a question of the body's ability to absorb oxygen. In athletic performances of longer duration, when the musculature has to work continuously at high tension, the ability of the organism to secure oxygen for the muscle tissues has a decisive effect on the working ability and endurance of the muscles. Vital capacity, or the amount of air we can get into our lungs, is thus by no means the only deciding factor. What matters is the extent to which the blood is able to absorb oxygen from the air in the lungs.

The body's capability of oxygen absorption also affects mental endurance, and depends upon the size and strength of the heart (minute volume and speed of circulation), the extensiveness of the network of capillary blood vessels, and above all upon the quality and the amount of blood.

Gothe described blood as "An entirely wonderful sap." A person weighing 70 kg has a total of about 5 liters of blood (approximately 5 quarts). Blood has the following composition: Plasma (50 - 60 % of the whole blood volume). The platelets (250,000 per cu. mm. of blood). The erythrocytes or red corpuscles (40 - 50 % of blood volume. 4½ to 5½ million per cu. mm. of blood.) The leukocytes or white corpuscles (5,000 - 9,000 per cu. mm. of blood, composed of 2 - 5 % eosinophils, 0.5 % basophils, 65 - 75 % neutrophils, 20 - 25 % lymphocytes, and 3 - 8 % monocytes). Plasma is 90 % water, 7 - 9 % proteins, 0.9 % inorganic salts, nonprotein nitrogenous bodies, nonnitrogenous bodies, blood gases, and special transport substances (enzymes, antibodies, and hormones).

The most important part of the blood with respect to capability of oxygen take-up constitutes the red corpuscles (Er) and its iron containing, red colored substance, hemoglobin (Hb), which lends the color to blood. The iron in hemoglobin readily combines with oxygen. Blood carries oxygen in the hemoglobin from the lungs to the muscle tissues.

It is clear that the more hemoglobin, i.e. iron, the red corpuscles contain (the redder the blood is) the more oxygen it will be able to carry from the lungs to the muscles. The more there are of these red corpuscles, i.e. the more blood the runner possesses, the larger the Hb surface which is available to combine with oxygen in the lungs and to deliver oxygen to the muscles. From the point of view of endurance it is therefore of primary importance to the runner that he possess as much blood as possible with as much iron in his blood as possible.

The hemoglobin content of the blood is measured in grams per 100 cubic centimeters, and "normal" human blood contains 14 to 16 grams of hemoglobin per 100 cc. The hemoglobin content of blood may also be described by percentage (some definite figure between 14 and 16 grams per 100 cc of blood is regarded as 100% --a figure which certainly must vary with altitude, environment, etc.) In Finland, 15.5 grams of hemoglobin per 100 cc of blood is considered 100%. Thus we consider 1.5 grams equal to 10%, 11 grams equal to 70%, etc. (14 grams is equal to 100% for women as 15.5 grams is equal to 100% hemoglobin content for men.)

The middle and long distance runner is hardly in top condition unless the hemoglobin content of his blood is 15-16 grams per 100 cc of blood (about 97- 103%).

Obviously the blood picture and particularly the Hb and Er values are of great importance to athletic performances. If these values are high, the amount of HB at least approximately 14.5 grams (93-94%), and the number of Er at least 4.7 millions, the runner may train at maximum intensity. But if these values are average, Hb 13.0 - 14.0 grams (83 - 90%) and Er about 4.2 - 4.5 millions, he should train with caution. If these values are low, Hb 12.5 grams (80%) and Er 4 millions or be-

:ow, he may do only very light training, or perhaps even rest and take medication prescribed by the sports-physician (iron and liver) until the blood values have increased favorably. If during training the blood values suddenly drop, it is a sign of too hard training.

It is noteworthy in connection with measured top values for blood that the following values were measured on the young Finnish skiier Mantyranta prior to the 1960 Squaw Valley Winter Olympic Games: Hb 18 grams (116- 117%), and Er 6.5 millions. (He won a relay gold medal.) On the Jamaican quarter-miler Herb McKenley, who once ran 440 yards in a world record 46.0, Er was measured while he was in top form at 6.8 millions. These represent maximum values. If the blood values exceed the above figures it is a sign of possible ill-health, the blood becomes too thick and "sticky", thus decreasing its mobility.

If the amount of Hb is proportionately smaller as compared to the number of red corpuscles, it is wise for the sports physician to prescribe medication containing iron. If, on the other hand, the number of red corpuscles is proportionately smaller, the sports physician may prescribe either liver extracts or vitamin B12, either in liquid form, injections, or tablets.

In the past an index value called "I" was calculated as the ratio between the percent Hb and the Er value in order to ascertain which deficiency, Hb or Er, was proportionately greater. Nowadays a more accurate method is used to determine the average volume of red corpuscles (the Hematocrit value, volume of red corpuscles/ number of red corpuscles). Normally the average volume of red corpuscles is 85-95 cu. mm. If the value obtained is lower than the normal figure it is a question of iron deficiency. If the value obtained is higher than normal it is a question of Er shortage.

Thus today one can hardly consider training of a higher order without cooperation with the sports physician. There is a definite advantage in following the blood picture. The Finnish sports physicians have found that if the athlete starts hard training, the blood and iron requirement of the organism increases. The result will be after a few weeks the blood plasma clearly increases, i.e. the volume of blood increases. This means, of course, a "thinning of the blood", i.e. the relative amount of Hb in the blood decreases. Later the Hb and red corpuscles begin to increase. When an equilibrium of blood composition in this respect has been reached again the athlete is close to top condition. The time required to reach this equilibrium, starting at the date the hard training began, will vary according to individual difference but normally takes three to four months. Therefore, when after three to six weeks of hard training a decrease in Hb is found, this may be regarded as a normal phenomenon and need not cause alarm, provided the drop does not exceed 1½ grams (10%). On the contrary, it seems advantageous to train so hard that it will influence the increase of blood plasma, causing a slight but temporary decrease in the relative amount of Hb. The plasma increase is a favorable sign because this is just what stimulates the formation of new Hb and new red corpuscles in the bone marrow.

At this early stage of training it is particularly advantageous to take such substances as iron, vitamin B12, and liver, as the bone marrow needs building material for the formation of red corpuscles. If the Hb drop exceeds 1½ grams (10%) the workouts have obviously been too severe.

Long duration training of the right kind may increase the amount of blood by 20%, or from 5 to 6 liters for example. Thus in final analysis we observe that the proper volume and intensity of hard training is the most important factor for increasing the capacity of oxygen take up, resulting in increased endurance and tenacity. During hard training it seems desirable to check the variations in amounts of Eosinophils, because a steep drop in Eosinophils indicates overtraining or overcondition. If the number of white corpuscles exceeds 9000, it means infection somewhere in the organism and before training is continued the sports physician will seek to explain this increase in white cell count.

Following the blood values of athletes is essential to modern training. The importance of blood tests, naturally, should not be overrated, inasmuch as plenty of research in this area is still needed. But blood test results have already become a means to guide the coach at critical workout stages when it is otherwise difficult to determine if workouts should be increased or decreased in intensity. As a matter of fact, I consider it absolutely necessary that blood tests be given athletes preparing for important competition for a period of at least six months, and a minimum of once per month during this half year.

BIOGRAPHY

Kalevi Rompotti is chief coach of all military forces in Finland. A former international caliber middle distance runner, he was a Fullbright scholar at Stanford University in 1956. Rompotti is well known to European readers as one of the top coaches of that continent.

Basic Mechanical Principles of Running

By John T. Powell, University of Illinois

Introduction. The practice of track and field skills is both art and science. The art is the application of the learned techniques as applied by that individual and the science is the successful acquiring and development of the fundamental principles of the event.

Technique and style are different. Style is purely individual... it is the person's own interpretation of the performance, limited by mobility, power, speed, strength, balance, and endurance plus the mental ability to adjust to the situation. Technique is the generally accepted composition of the event, the recommended way it is done, conditioned by certain restrictive rules, and is the best way within these rules to apply basic principles of force and work. Thus, art and style are allied, as are science and technique.

Running. Force is that which alters the state of rest of a body or its uniform motion in a straight line. A single force applied to a body which is free to move causes movement in the direction of the force. If we have two forces acting in the same direction (and at a common point) the magnitude of the resultant force equals the sum of the magnitudes of the individual forces. Why, then, do some of us tell an athlete to drive from the blocks with only the front foot!

It is not the fastest started who wins the sprint, except in a very short dash. It is the athlete fastest at getting into his running stride and able to apply his force.

Naturally, the shorter man will be a faster started but that doesn't mean he will be first at the finish.

Admittedly the blocks are not together and neither are the feet in the "set" position, but if the force applied immediately as the gun reports is from both feet, then the athlete will be driven farther and in a more balanced way than if the force is only from one foot. This also gives the body a better chance of more horizontal drive, with less resistance to forward flow of movement. Again, this enables the rear foot to come through in a longer first stride and eliminates all "pattering" at the start. Try it!

An athlete should never run... or be trained to run... on a line. Rather he should be encouraged to run in a line. We have to consider the precariousness of balance of a runner... the swing of the hips caused by on line running is reflected again in the hips and shoulders... the arms then have to attempt to counter this rotation and are thus not contributing fully to forward propulsion.

The longest stride of anyone in any race is noted in a sprinter at full speed. It is not that the sprinter consciously tries to increase his stride length, it is that the length of stride is automatically increased because of the speed at which he is traveling. An athlete is encouraged to get his feet to the ground fast as this stops "bounding" or "floating". Time in the air is wasted time, since it is speed along the ground which matters.

Where then should force be applied? Under the body and for as long as it takes for the body weight to pass over the point of support. Should it matter how high the heel flicks up behind? No! We are interested in speed, and a short lever (radius) travels faster than a long one. With the lower leg out of the way the thigh can swing through fast for the next stride. The faster the athlete, the higher will rise the heel behind. The heel's rise is thus proportional to the force exerted and is a reaction to the power used.

This principle applies to the arm action as well. A long low action, or one which alternates from bent to stretched, will create a bounding type of run because of its slowness. As the speed of the arms determines the speed of the legs, a short radius moved through a full range will give faster leg action. Again, the arm action should be forward and back, rather than across. This will enable the body to move in a straight line and, as this is the shortest distance between two points, it is the quickest. If the sprinter's hands cross the mid-line of the body in their drive forward they will create a rotary movement which will be reflected in the hips... countered and transferred to the feet. It is easy to see the curvy progress our athlete will make. Conversely,

if the feet are placed on the track other than straight forward and back, not only will power be dissipated, but a rotary action will be caused from the ground which will have repercussions throughout the body in accordance with Newton's third law of motion.

A body will continue in a straight line unless acted upon by another force. This rotating action would not only alter the application of force, but this change in direction will alter the velocity of the body. Hence, a 220 yards dash on a straight-away is faster than one around a curve. The athletes do not have to be continually changing their point of application of force to keep going in a straight line. How foolish it is then to teach different finish techniques than a straight run through the tape. Any alteration to forward momentum such as by a leap, throwing up the arms, dropping the trunk down, creates new forces, which have to be countered, thus altering the forward motion.

Mass times velocity equals momentum. If two runners are running at the same speed but one performer is heavier than the other, he is generating more momentum than the lighter one. It is likely that if the race is a longer sprint and all other factors being equal, the heavier man will win. It is certain the heavier will require a longer distance to ease down after the effort. It is not fair to expect a big and tall man to win a very short dash as it takes time for him to generate his forces through longer muscles, longer levers, and a longer response time from the nervous system. However, once at full speed and in full stride he will be more difficult to stop, and so it appears that big men often win "on the tape," having by then shown superiority.

A small man may achieve his maximum running speed at say 40 yards in a 100 yards dash. It is then a matter of sustaining that speed for as much of the remaining 60 yards as possible. The greater mass of the more powerful athlete will achieve its maximum speed at perhaps 45 yards, which leaves a less distance for sustaining speed. Hence the big powerful dash man appears to "come through" late.

The amount of force which an athlete must use to increase his speed is in direct proportion to his velocity increase (Newton's second Law of Motion). How does an athlete increase his speed? We know that in work a muscle fiber contracts maximally or not at all. We know that muscles only pull, and we know that the magnitude of a muscular force is in direct proportion to the number and size of the fibers in the muscles which are contracting. This suggests the advantage of heavy resistance work and weight training.

Power is the speed with which force is exerted and force is described in terms of its magnitude, direction, and point of application.

Watch an athlete from the back... watch for "stand up and run" indicating a poor "set" start position with inadequate forward lean. Note how the feet come up behind in the first eight strides. This will tell direction of application of power. Note the angle at which the foot is placed to the ground, showing ability of the athlete to apply force forwards, or otherwise. Note angle of body and its gradual rise, showing whether there is an increase in the application of the force on each subsequent stride.

Sometimes we see an athlete, directly after the start, flicking heels across from one buttock to another... but does it matter? Yes, and no! The direction of muscular force is determined by the relation of the tendons of the muscles to the mechanical axis of the part which is acting (if an athlete is bandy he cannot help crossing heels at the back). The angle between a muscle's line of pull and the mechanical axis of a bone is termed the angle of pull. This is not fixed for every muscle... it changes with every degree of motion.

The angle of pull is increased by making a longer pull, so a force is best applied at an angle... and the right angle is best. This is one reason why coaches are recommending more and more a reversion to the "medium" start by sprinters. The bunch (or bullet) start, having the bend at the knee which is less than a right angle in each case, composes two forces... a rotary one and a stabilizing one. Thus before a muscle can work maximally it first has to overcome its antagonist. Small, compact, and powerful athletes can, however, often use the "bullet" start for a fast getaway. Don't expect a tall, powerful performer to use the "bullet" start.

Friction can aid and hinder a runner. This depends upon the type of surface, the size of the part of the foot placed to the ground, and particularly where (in relation to the body) the ball of the foot is placed to the ground. Force is best applied, and friction is less, directly under the

center of gravity of the body. But the body is moving and so is the force-application spot.

If the foot is flicked from the ankle and the leg appears straight on landing for its stride there must be a resistance to forward motion. It will be lessened if the knee is then bent but by this very process the body will have dropped and a bounding type of run introduced... very wasteful of energy and forward propulsion.

In most dash men the front leg on coming to the ground is slightly bent. The weight travels over the foot, then the drive should be exerted for as long as possible... the length of drive depends upon the speed attained. If the spikes are too short then frictional advantage will be lost. If too long then friction will be increased. One must also consider this in the wearing of socks. If the spiked shoes are too large and are only made snug by socks, then there will be a slipping (friction) by the foot in the shoe and a consequent increase of friction by the shoe on the track. Again, grass tracks are "slower" than composition tracks, because of the frictional resistance given by the grass to each step taken.

Finally, look to the cinders to see the progress of your athletes, progressive stride length, depth of impression when ball of foot strikes ground, whether there is a cinder trail behind the foot marks, and so on. Each tells its story in the application of power and force in running.

BIOGRAPHY

John T. Powell, former track coach and lecturer in physical education at Rhodes University in South Africa, is currently completing work for the Doctor of Philosophy degree in physical education at the University of Illinois. Few coaches today can equal his background in academic training, experience, and success. He is a graduate of Britain's top school of physical education, Loughborough College, served seven years as a British Army Officer during World War II, holds the British Senior Honorary Coaches award, received the Master's degree while studying as a Fulbright scholar at the University of Illinois, and produced many of South Africa's brightest stars, including Malcolm Spence (world's No. 1 ranked quarter miler in 1959, who has clocked 45.9 in 1960), J. W. Truter (South Africa High Jump champion), Eryll Brill (ex-South African H.S.J. recordholder), Clifford Larter (1:50.1 in 1959), Neil MacDonald (52.2, 440 yds. hurdles, 1960), Esther Brand (1952 women's Olympic High Jump champion), and numerous others including internationals from Denmark, Scotland, and India. After 12 years at Rhodes University, John has emigrated to the USA, where he will continue his coaching career following completion of his doctorate. South Africa's loss is America's gain, and it could not have happened to a finer man!

STRESS AND TRAINING (continued from page 6)

specific stress will increase resistance to that stress, but at the expense of reducing non-specific resistence to other stresses. Any stress draws from the body's finite quantity of adaptation energy. Those stresses for which the body is less well adapted will make the greatest demand on the body's store of adaptation energy, and be most apt to hasten exhaustion reactions.

Speaking at a symposium on training in Sydney during July, 1955, University of Sydney Physiology lecturer Forbes Carlile (himself a former marathon runner and now an Australian Olympic Swim Coach) emphasized the great responsibility involved in the training of an athlete due to the use of two of his very important personal attributes - the athlete's time, and his powers of adaptation to life's stresses. Carlile compared training the athlete to bending a green twig. The body may eventually mold itself to the force of continuously imposed physical exercise, but a little too much and the body, like the twig, may show signs of strain. The breaking point may be reached with the application of more stress. Thus, according to Carlile, regardless of future coaching efforts becoming more scientific with better organization of knowledge, the art of coaching will continue to lie in recognizing individual differences and the mixing of training routines with sufficient rest to produce the optimum amounts of specific adaptation and adaptation energy.

Science and Art of Coaching

By Dr. A.H. Ismail
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Is coaching an art or a science -- that is the question? The author is of the belief that coaching is both an art and a science. At this point, two questions present themselves, namely; what constitutes the science of coaching? and what constitutes the art of coaching? In order to answer the first question, let us examine a few among many competencies which make a good coach.

First, a good coach should have an adequate knowledge of anatomy. Salient anatomical features should be clearly understood. He should know that each muscle fiber is composed of a fluid portion, the sarcoplasm (muscle cytoplasm) and a large number of myofibriallae or sarcostyles which are the contractile elements. (1, 2)

Knowledge of types of skeletal muscles and their function are of prime importance. There are two types of skeletal muscles: (1) white (pale) muscles which are specialized for speed rather than strength; and (2) the red muscles which are capable of slow, powerful and long continuous contractions.

In general, muscle contraction can be classified into isotonic and isometric. A classification which provides a better framework for the muscle may be listed as follows: (1) Concentric contraction (this type of contraction overcomes gravity or resistance and produces motion); (2) eccentric or lengthening (this type is of considerable significance in co-ordination and regulation of speed of movement in which the part already in motion may exert considerable momentum); (3) static contraction (this type has a stabilizing effect); (4) guiding action (during this action, muscle does not actually perform motion but controls the direction of motion).

Each muscle fiber is supplied by a separate branch from a motor nerve. As this nerve fiber penetrates the sarcolemma, it breaks up into several ramifications which terminate in a specialized mass of myoplasm known as the motor-end plate. In addition, muscles are also provided with sensory nerve endings embedded in the connective tissue between the muscle fibers and in association with the tendons. Pertaining to sympathetic nerve supply, there is no positive evidence as to its supply to skeletal muscle as claimed by some; however, the consensus is that the sympathetic nerves present in the muscle are vasomotor to the blood vessels. The role of the nervous system in muscular activity is primarily perfection of speed and accuracy with which the nervous system co-ordinates and correlates muscle action.

Each muscle is richly supplied with blood which comes through one or more arteries which branch freely and provide an extensive capillary network. Krogh (3) reported a great increase in the number of patent capillaries in activated muscles. Petren (4) et al noted an increase of about 45 per cent in the number of capillaries in guinea pig muscles during exercise as compared with those that were not exercised.

Second, chemical composition and changes in muscle during contraction should be clearly understood by coaches. The proteins of muscle are nyosin, globulin, myogen, actin, and stromaprotein. Myosin is considered as the contractile substance of muscle pertaining to the chemical changes in muscle during contraction, the consensus of most recent evidence suggests the following simplified sequence of chemical events during muscular contraction and recovery; (1) The breakdown of adenosine triphosphate supplies energy to initiate the muscular contraction which is believed to be due to a physical alternation of protein myosin (5, 6); (2) Breakdown of phosphocreatine supplies the energy required for the resynthesis of adenosine triphosphate; (3) the breakdown of glycogen to lactic acid provides the energy needed for resynthesis of phosphocreatine; (4) approximately a fifth of the liberated lactic acid or the carbohydrate resulting therefrom is oxidized to provide energy for the resynthesis of glycogen from the remainder of the

lactic acid produced (oxygen is essential for this step).

Third, physiologic effects of muscular exercise should be thoroughly known. The above four steps illustrate the transformation of energy in muscles. Lactic acid production is one of the fundamental chemical reactions that produce energy for muscular contraction. When oxygen intake is not present, muscular contraction is this case is essentially an anaerobic process.

Oxygen debt may be defined as the amount of oxygen used (over the resting amount) during recovery from exercise or work. There is a direct relationship between the lactate in the blood and the magnitude of oxygen debt. (7) The ability of muscle to accumulate oxygen debt is very useful. At this point it is important to point out two phases that take place during muscular work; (1) initial states and (2) steady state. In the initial states, the metabolism does not rise immediately because of lag in the circulatory and respiratory adjustment at the beginning of work, while in the steady state, the intake of oxygen meets the needs of the muscle.

The primary goal of every coach is work efficiency. Efficiency may be interpreted by the following formula: $E = \frac{W}{Q}$ where E = efficiency, W = energy expressed, and Q = total energy developed.

The efficiency of human muscles ran from 21 to 25 per cent. This means that a small fraction of chemical reaction is transformed into energy while most of the remainder is transformed into heat. The result is the increment of body temperature. The magnitude of this rise in body temperature depends on the severity of work and on other conditions, such as clothing, obesity and humidity of the environment, etc. This rise in body temperature speeds up most of the processes in the body, metabolic and otherwise, among them the frequency of the heart beat. The following are some specific physiologic effects of co-ordinated and organized muscular activity on the muscles themselves: (1) Change in muscle structure as evidenced by the thickness and toughness of the sacrolemma of muscle fibers and the increment of the amount of connective tissue within the muscle. (2) Activation of the unused fibers that have become small from lack of use thus muscles increase in size; (3) increase of strength; (4) gain in endurance which is a result of the improved quality of chemical changes that take place within the muscle fiber, (5) increase in hemoglobin content in the muscle fibers. Whipple (8) found that a greater amount of hemoglobin is present in the muscles of active dogs than in the muscles of inactive dogs (9). Facilitation of end-plate; there is no clear cut scientific evidence which supports this point, hence, the conclusion pertaining to this concept is purely empirical, (6) increase in number of capillaries, comparing the trained and untrained animals, it was found that the number of capillaries was increased by 40 to 45 per cent in the trained ones.

Fourth, the coach should know the work capacity of each individual comprising the squad. Work capacity could be defined as the highest level of metabolic load which can be compensated for adequately by optimal co-ordination of the functional reserves.

The most objective criterion of work capacity as defined, is the maximal oxygen consumption as a measure of circulatory and respiratory adaptability. The correlation between work intensity and oxygen requirement per unit body mass is so well established, that one is able to predict a person's total oxygen intake for a known work intensity. The following linear equation proved to approximate very closely the average values of oxygen intake utilizing a treadmill: (10)

$$Vo_2 = VXW \times \left(.073 + \frac{OC}{100}\right) \times 1.8$$

Vo_2 = the oxygen consumption in mL/min (STPD) , V = the treadmill speed in meters/min., W = the body weight in kilograms, oc = the treadmill angle in per cent, 1.8 = the factor constituting the oxygen requirement in mL/min for 1 meter-kilogram of work.

Pulmonary ventilation (per unit of body weight) serves as a somewhat better indicator of work efficiency than the oxygen consumption. Greater work capacity is associated with a greater respiratory efficiency and usually, with a greater maximal breathing capacity.

Fifth, knowledge of the phenomenon of "fatigue" is indispensable to the coach. Fatigued muscles lose irritability and contractibility. Fatigue products are responsible for this state which accumulate due to over production of wastes, or faulty elimination, or both. Following are some of the major factors which influence the progress of fatigue: (1) frequency and rate of work carried, (2) amount of rest periods provided, (3) amount of load carried, (4) fitness of the

individual, (5) working conditions, (6) the manner of carrying out the load.

Sixth, knowledge of mechanics is of prime importance. In order to illustrate the importance of this concept, let us examine the mechanics of pole vaulting. There are two pendulums involved in pole vaulting: (11), (1) the pendulum which is created by the pivoting of the pole in the box with a vaulter free to swing near its upper end, (2) the pendulum which is created after the vaulter's body travels through an arc which revolves itself into a parabolic curve. Analyzing the mechanics that take place in these two created pendulums, it is reasonable to conclude that the optimal efficiency in vaulting can be reached when the grip is as high as possible, the pull is delayed as long as possible giving the maximum reach with the maximum effort. Absence of this kind of knowledge will never achieve the maximum outcome.

Seventh, a coach should be a good psychologist. The coach is dealing with human beings who have different moods, temperaments, goals, etc. Dealing with his squad as individuals, he should help each member in realizing his needs. In doing so, frequent counseling periods are required during which the coach utilizes several approaches and techniques to help each individual so he can help himself.

Eighth, a coach should realize the importance of research. As a matter of fact, he should look at research as indispensable for his success. It is a very well known fact that a coach does not have the time for conducting research. However, he should encourage and assist others in doing research in his field. In order to illustrate the importance of research, Ganslen assisted by Hall, studied the acrodynamic forces which influence javelin flight. (12) The general assumption pertaining to a superior throwing technique has been developed due to the fact that there is sudden dramatic improvement in the world javelin record. Ganslen rejects this assumption due to the absence of evidence from any source which suggests that modern javelin throwers have developed superior techniques. In addition, some evidence was found that this improvement in world javelin record resulted from the major changes in javelin design, most notable of which, was a marked increase in surface area. Supported by this evidence, rules and regulation pertaining to this particular event have to be examined and make the necessary changes.

Examining the above important competencies that every coach should have, it is reasonable to conclude that coaching is a science. Scientific coaching is based on facts which have been verified and proved. Where does the art of coaching enter into the picture presented above? The implementation of these scientific facts constitutes the art of coaching.

BIBLIOGRAPHY

1. Jordan, H.E., "The Structural Changes in Striated Muscle During Contraction," Physicl. Rev., 13:301-324, July 1933.
2. Speidel, C.C., "Studies of Living Muscles: II. Historical Changes in Single Fibers of Striated Muscle During Contraction and Clothing," Am. J. Anat., 65:471-529, November, 1939.
3. Krogh, A., The Anatomy and Physiology of Capillaries, Yale University Press, New Haven, Connecticut, 1939.
4. Petren, T., Sjostrand, T., and Sylven, B., "Der Einfluss des Trainings Auf die Hanfigkeit der Capillaren in Herz-and Skeletmuskulatur, "Arbeitsphysiel, 9:376-386, July 1936.
5. Needham, D.M., "The Adenosinetriphosphatase Activity of Myosin Preparations," Biochem, J., 36:113-120, February, 1942.
6. Bailey, K., "Myosin and Adenosinetrophosphatase," Biochem, J., 36:121-139, February, 1942.
7. Wakim, Khalil, G., "The Physiological Aspects of Therapeutic Physical Exercise," The Journal of the American Medical Association, 142:2:100-108, January, 1950.
8. Whipple, G.H., "The Hemoglobin of Striated Muscle," Am. J. Physiol., 76:693-707, May, 1926.
9. Fenn, W.O., Cited by Lloyd, D.P.C., Functional Activity of Muscle, in Fulton, J.F, Howell's Textbook of Physiology, Philadelphia, W.B. Saunders Company, 1946, Chapter 2, p. 32.
10. Balke, Bruno, and, Ware, Ray W., An Experimental Study of "Physical Fitness" of Air Force Personnel, Department of Physiology-Biophysics, U.S. Air Force School of Aviation Medicine Randolph Air Force Base, Texas.

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11. Ganslen, R.V., Mechanics of the Pole Vault, John S. Swift and Co., St. Louis, Missouri, March, 1959.
12. Ganslen, R.V., and Hall, Kenneth G., "Aerodynamic Forces Which Influence Javelin Flight," paper prepared for the College Physical Education Association, Cincinnati, Ohio, December, 1959.

BIOGRAPHY

A.H. Ismail was born in Egypt and represented that country in basketball at the 1948 Olympic Games. At the Helsinki Olympics in 1952 he represented Egypt in fencing and basketball. One of the brightest basketball stars ever produced in Europe, Ismail has performed on the hardwood courts of Paris, Prague, Barcelona, Moscow, Buenos Aires, and countless other cities throughout the world. He is a graduate of Cairo University, and received his doctorate from Indiana University.

Book Review

PHYSIOLOGY OF EXERCISE

(Third edition)
By Laurence E. Morehouse and August T. Miller
Published by the C. V. Mosby Co., St. Louis, Mo.
Pp. 349. $4.75
Reviewed by Fred Wilt

Originally published in 1948, the second edition appeared five years later. This third edition was written in 1959 with extensive revision in accordance with rapid advances in physiological knowledge made possible by developments in research instruments. In writing this book, the authors have assumed the reader has only an elementary knowledge of some of the basic principles of chemistry and physics. Accordingly, they have included essential physiological background material necessary for an understanding of the response of the body to exercise.

Physiology of exercise is an area of knowledge of paramount importance to the track and field Coach and Athlete in search of more scientific training methods and better performances. The authors have produced a most useful study in which principles related to physical education, athletics, and work performance are related in an interesting manner

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The Oxygen Debt Mechanism

The oxygen debt by definition is the difference between the oxygen taken into the blood stream during the exercise and that which is required by the muscles during the specific exercise under consideration. By virtue of the body's (muscles) ability to defer its oxygen consumption temporarily, we are able to work the muscles maximally for short periods of time and recoup this loss by a high post exercise oxygen intake. In reality, the debt mechanism would be better called the "post exercise oxygen consumption." The oxygen debt makes itself felt in a dramatic fashion by the violent post exercise respiration. This knowledge has falsely led some not too careful scientists, trainers and coaches to use 100 per cent oxygen feeding after exercise to help the athlete recover. Dr. Erling Asmussen of Denmark demonstrated 12-13 years

(continued on page 18)

The Discus Throw

By John T. Powell

The performance of the discus throw is described from the initial stance in the circle to the end of the reverse. Certain typical faults, and their correction, have been included for the guidance of coaches.

GENERAL: The whole of the 8'2½" circle should be used. To do this properly, and to insure greatest controlled speed across the circle and maximum applied power into the discus, the initial stance should be efficient. THE MOVEMENTS PERFORMED HERE DETERMINE THE SUCCESS, OR FAILURE, OF THE WHOLE THROW.

INITIAL STANCE AND PRELIMINARY SWINGS: The athlete should stand with side or with back to the direction of throw. It is not necessary to vigorously "waft" the discus about or to indulge in violent "winding up" movements. These not only tire but disturb the body's balance. Simple swings are best. Preliminary swings are performed solely to: (1) overcome the inertia of the discus; (2) get the missile as far behind the body as is controllable; (3) give the body the maximum range of movement. More than two swings should not be necessary.

THE TURNS: The body starts to turn when the discus has reached its farthest backward movement in the preliminary swing. With the rear knee bent, the body upright (but not stiff) and the discus far back, the front foot makes a short movement towards the circle's center. The "seat" moves down, (back still erect) giving the impression of the athlete about to sit on a chair. This "sitting" movement sets the body in motion. The weight is transferred over the front foot DRIVEN by the action of the rear leg. Many mistakes originate here. The body must not simply pivot around the legs but should be driven through the turns, across the circle by the power of the leg drives.

The turn I advocate is the "jump" turn. In this the rear foot comes off the ground AS LATE AS POSSIBLE and the spinning movement on the forward foot performed for AS LONG AS POSSIBLE. This ensures maximum control, preservation of continuity and both feet are off the ground for a very short time. It is not the height of the jump which matters -- but the CONTINUITY OF MOVEMENT.

The rear foot should be picked up and brought into the front half of the circle with a running action. "Run over" the spinning leg (knees close together) is a very useful suggestion to be made by a Coach. This will stop any tendency for the back leg to swing into position. When the leading foot lands, the body's weight should be transferred over it, the body will be turned back, the discus still behind it. The toes should be pointing more to the rear of the circle than across it.

The final half turn is through almost 180 degrees on the ball of the rear foot. During this time the "spinning" foot should have been picked up and, with knees passing close together, carried on its uninterrupted way (heel leading BUT ball of the foot touching first) to the ground just inside the front edge of the circle and, very slightly to one side of the line of direction of the throw.

THROWING POSITION: The body has already completed a 360 degrees turn, the forward (erstwhile "spinning") foot is very close to the ground, reaching forward slightly to the side of direction of throw but, already, BEFORE THE FRONT FOOT TOUCHES THE GROUND, the actual THROW ACTION should have commenced. This eliminates any possibility of a "dead pause", common in many throws, and so wasteful of the momentum gained. As soon as the forward foot is DOWN (this is a left foot for a right-handed thrower) the rear hip should be driven forward and upward vigorously. Now the slinging arm comes fully into action (at the same time) and the WHOLE MOVEMENT is continued forward and around. If this is done a reverse of the feet will become necessary, but must not be done before the discus has been released.

The action of the head throughout should lead the body's movement.

The free arm should be used as a balancer and to keep the plane of the shoulders high. The arm should hang loose and, at the moment of delivery, should aid with a downward driving of the elbow, making for a strong movement and helping the body to stretch.

The discus should be kept approximately in the same horizontal plane throughout the turns, and should be released at an angle of from about 32 to 35 degrees to the ground. At the moment of release both feet should be on the ground.

COACHING NOTES: Effective coaching depends upon the ability to distinguish between fundamental and minor faults. The good coach should always correct the major fault first, however unspectacular the end result may seem.

In discus throwing he should remember that the reason for the turns is to get SPEED into the discus. However, the athlete must arrive in the throwing position with no loss of continuity, having sufficient room to throw with maximum effort; and in the most efficient position to apply his power for the longest possible time. Therefore, SPEED should not be stressed until all movements in the throw are correctly blended.

The coach should insist that the athlete (suitably apparelled) practices in a correctly marked circle, with a discus conforming to specifications.

When coaching the various phases such as the initial stance , the pivots, delivery, and reverse, be certain to blend each correction into an actual throw before being content that the corrected phase fits in smoothly.

SOME FAULTS AND THEIR CORRECTION: (1) The grasp on the "plate" should not be tense, nor should the discus be held at an angle towards the wrist. (2) Preliminary swings are often too many and too vigorous, upsetting the body balance. They should be few and easily made, with the feet a natural easy distance apart. The performer should look, and be comfortable. (3) Correct any tendency to stick out "the seat" whilst turning as this would spoil the balance of the whole movement. (4) When an athlete takes a TOO LONG step with the front foot there is an automatic cessation of movement and the continuity of the whole throw is jeopardized. Again, in a TOO SHORT foot placement there is a loss of drive from the rear foot and a spin results, without forward propulsion. (5) Discus throwers are inclined to initiate the turn by a dropping of the forward shoulder, forgetting that the head is the "rudder" of the body. This will lead to a "swooping" action, wasteful of energy and difficult to control. The head should lead the turning action. (6) Very many throws are spoiled by a "dead stop" on landing from the 360 degrees turn. It must be stressed again that the actual throw should be started AS SOON AS THE REAR FOOT HAS LANDED. (7) After the rear foot has landed many throwers simply "stamp" the front foot into place, neglecting to cultivate a "flow" of movement forwards ALL THE TIME. The front foot should be dropped to ground and the body's weight allowed to travel over it. (8) Some competitors place the front foot across the line of direction of the throw, thus stopping the hips from acting to their full limit and causing the discus to FALL TO THE RIGHT (for a right-handed thrower). If the front foot is grounded too late OR too far to the left side (for a right-handed thrower) the action of the hips is not limited, there being no resistance to their power, the body falls away and the "platter" SWINGS WIDE TO THE LEFT. (9) In the turns, if the discus is carried too close to the body, there is a tendency to "undercut". Also the athlete is often noticed to jump at delivery. The slinging arm should be allowed to swing well out and discus released in line with the shoulder. The jump at delivery noted here is symptomatic of a too fast (and uncontrolled) turn. The discus being so close to the body allows it to spin very fast. To stay in the circle the athlete sometimes, (wrongly) jumps. (10) Another cause of "jumping" at "take-off" is when the feet are too close together in the fore-part of the circle. Coaches should focus attention on the position of the rear foot as it comes to the ground for delivery. It should be approximately in the position of "toes back to touch the center line." (11) Both feet must be on the ground at the moment of delivery. If not, the accumulated speed is dissipated at the moment when it is most needed. (12) Some throwers are inclined to "bowl" the discus over their shoulder. This is caused by a falling away to the side of the supporting leg. This "support" has been kept bent, the body, moving forward and around receives no check the free arm pulls the body down and the slinging side is elevated. To correct this tendency coaches should instil into their athletes the need for a gradual straightening of the front leg - in the throwing position - and, at the moment of a throw, a complete stretching throughout the body from the toes of BOTH feet. (13) In following through hard, some performers fall away to the side opposite to the slinging arm. To correct this, stress the need to look at the flight of the missile until it has landed. (14) An otherwise good throw may be spoiled by a restricted follow-through of the slinging arm. A correctly performed follow-through

imparts more spin and a longer application of power to the discus.

REMEMBER: (1) Timing and co-ordination of the WHOLE throw is most important. (2) Gradually accumulate speed throughout the throw until "explosion" force is reached at the end. (3) From start to finish the discus throw should be a progressive movement, not merely a series of pivots. The weight should always be moving forward. Consider the whole throw as an accumulation of power and momentum, gradually increasing until the discus is released with maximum speed and force.

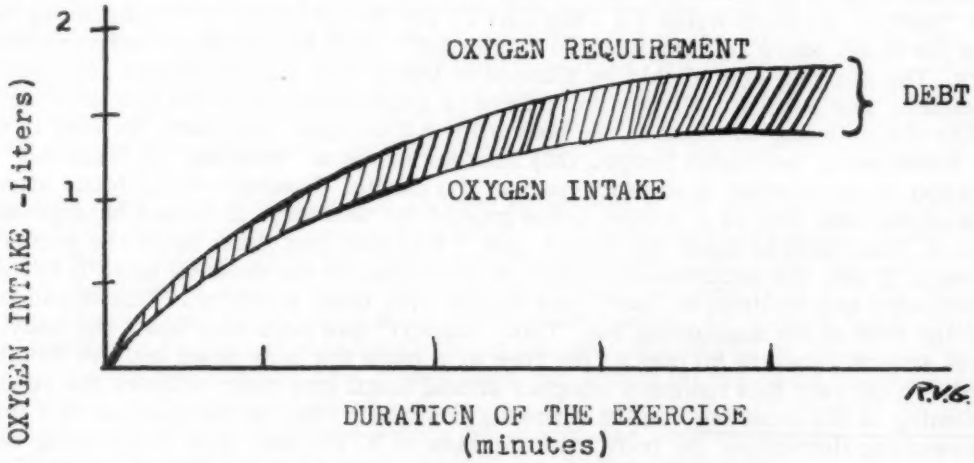
OXYGEN DEBT (continued from page 15)

ago that the post exercise feeding of 100 per cent oxygen does not speed up the repayment of the oxygen AT ALL. We are thus forced to emphasize that the recovery of the muscles depends upon biochemical changes in the liver or muscles which a higher concentration of oxygen cannot influence. Oxygen feeding is therefore 99 per cent hokum and psychological. This is in no way similar to the phenomena of feeding oxygen in airplanes or in skin diving. If the athlete could carry oxygen on his back he could probably raise his oxygen intake by 1000 cc per minute as a minimum. This is illegal!

The longer the exercise the lower the oxygen debt. Marathon runners develop their debts only in the last half mile or so of the race when they speed up for the finish. In steady running the oxygen debt is built up very slowly or not at all.

It is my opinion that the difference between the champion and the average runner which results in a high oxygen debt is the willingness of the champion to ignore the pains in his muscles which are a warning of a cumulative debt. The poorly trained and inadequately motivated athlete either slows down or quits at this critical time... thus he shows a low debt in laboratory tests.

The oxygen intake is determined by two major factors, a high cardiac output and perfect blood condition (hemoglobin and red cells). In order to reduce his requirement to a minimum (and thus lower the debt) he must run efficiently. No extraneous muscle movements, complete relaxation, minimum changes in pace and no bouncing up and down. The cardiac output maximum is affected by training and inheritance. The condition of the blood is susceptible to nutritional factors which can be controlled. Variations in the oxygen debt on successive days with identical laboratory tests, or on the field, may be a reflection of warm-up, environmental factors of vague origin or our lack of knowledge of muscle biochemistry. No human is the same biochemically from one hour to the other let alone from one day to another.



Max O_2 intakes may reach 5.1 L/min

A Review of Selected Mechanical Principles

by Fred Wilt

As the never ending search for better performances in track and field athletics grows more intense through competition provided by increased numbers of participants and greater interest by the public in general, those who practice the art of coaching will turn more and more to the sciences for information calculated to direct their efforts. Among others, this includes the science of mechanics.

Mechanics is the branch of physics which deals with the interrelations of force, matter, and motion (7, p. 1). Body mechanics, which is defined as the application of physical laws to the human body at rest or in motion (1, p. 328), is a topic of specific and paramount interest to the coach and athlete seeking to justify currently accepted techniques and develop more efficient and effective skills in the performance of the various events.

Certain terms should be reviewed prior to further consideration of the science of mechanics.

FORCE. This refers to what is commonly known as push or pull. Force varies directly with the square of the velocity (2, p. 99). When we exert force on an object by muscular effort, the body is in contact with the object on which force is exerted, and this is known as contact force. There are also forces which act through space without contact, known as action-at-a-distance forces. The force of gravity exerted on a body by the earth, known as weight, is the most important of the action-at-a-distance forces in consideration of body mechanics. All forces fall into the class of either contact forces or action-at-a-distance forces, a fact that will be found useful when deciding specifically what forces are acting on a given body or object. Thus it is necessary to observe what bodies are in contact with the one under consideration. The only forces acting on the object are then the forces exerted by the bodies in contact with it, plus the gravitational force or weight of the object. The forces acting on an object or body which are exerted by other bodies are external forces, while forces exerted on one part of a body by other parts of the same body are internal forces (7, p. 1).

CENTER OF GRAVITY. The force of gravity is always acting on a body, in a vertical direction downward, toward the center of the earth. Practically speaking, gravity pulls on the weight center of the body (4), or the body s center of gravity. The body's center of gravity may be described as the point about which a body balances, or the point at which the weight of the body is concentrated. Regardless of the irregular shape of a body, it has center of gravity or point about which it will balance.

The center of gravity in the human body is located in the middle of the trunk and at about hip level when standing in the normal erect position, with the arms hanging at the side. Any movement of a body part will alter or shift the center of gravity in the direction of movement. For example, if the arms are lifted above the head while in the normal standing position, the center of gravity will be raised upward. This change in position of the center of gravity with movement of a body part is instantaneous. External weight added to the body will increase the total body weight and affect the location of the center of gravity, moving it in the direction of the added weight, producing a common center of gravity of the body and the added weight.

EQUILIBRIUM. When the resultant forces on a body is zero, it is in equilibrium or at rest. If a force equal to the body's weight (or the pull of gravity) can be applied vertically upward at the center of gravity of the body, the body will be supported in equilibrium, regardless of how it may be turned about its center or gravity (8). Gravity pulls toward the center of the earth, and a line passing from the body's center of gravity downward toward the earth's center may be referred to as the line of gravity (1, p. 22).

A body is balanced or at equilibrium when its center of gravity is over its supporting base. It loses balance or equilibrium when the center of gravity falls outside the base. Thus the larger

the base, the more stable the body, since the center of gravity can move farther without falling outside the base. Conversely, the closer the center of gravity falls to the edge of the base, the more precarious is the balance. Thus throwing the center of gravity outside the base is necessary to initiate motion (2, p. 17).

A freely falling body travels at a uniformly accelerated rate of 32 feet per second in a vertical direction, regardless of size or weight. It decelerates at the same rate if going up (2, p. 24). If one body falls freely from rest and simultaneously another body is projected horizontally from the same height, both will strike the ground at the same time but at different places.

Two types of measurements are used in problems of mechanics. (1) Scalar quantities, which have only magnitude (such as weight, volume, and area), and which may be added arithmetically if of a similar nature. (2) Vector quantities, which have magnitude and direction (such as velocity, momentum, force, acceleration, and displacement), and which may not always be added arithmetically (6, p. 109).

VECTOR DIAGRAMS. Vector quantities are often graphically illustrated with arrows, the direction of the arrow representing the direction in which the quantity acts, and the length of the arrow, drawn to scale, representing the magnitude of the quantity.

PARALLELOGRAM OF FORCE. When two forces are simultaneously applied to a point in a body, the resultant of these forces is always the diagonal of a parallelogram from that point. By means of a scale and protractor, one may arrive at a rough solution to such a problem when the separate vector quantities are known. This represents a vector analysis of the problem. The resultant of two or more forces acting about a point may be more accurately determined mathematically when these forces are known (7, p. 8).

MOTION. Motion may be defined as a continuous change in position, and is the primary element in most athletic events. There are two types of motion, and all movement may be regarded as essentially one or the other, or a combination of the two.

LINEAR MOTION. One type of motion is linear (also known as translatory) motion, from one point to another, as a whole, in a straight line.

ANGULAR OR ROTATORY MOTION. The second type of motion is angular or rotatory motion, consisting of movement of a body in a circle or arc about a center of rotation (7, p. 141). In rotatory motion the linear speed of a point in rotation is directly proportional to the distance of that point from the center of axis of rotation (2, p. 51).

CURVILINEAR MOTION. Frequently circular motion is indicated as a third type of motion which is actually a type of angular motion if all parts move in an arc about an axis, or curvilinear if the object moves as a whole in a circular path (1, p. 36). Theice skater negotiating a figure eight represents curvilinear motion as he moves in a curved path, but is not rotating about an axis with which he is in contact. The flight of the javelin, discus, shot, or hammer might serve as another example of curvilinear motion. The motion is linear at the start, but friction, gravity, or air resistance act upon the object to make the motion curvilinear. It is possible for this curvilinear motion to be an actual arc, or even a complete circle (1, p. 35).

DISPLACEMENT. In linear motion a change in position may be measured in any appropriate unit, such as meters, yards, feet, miles, etc. The direction of displacement may be expressed with respect to vertical or horizontal planes, points on the compass, or any other plane or reference (6, p. 113).

VELOCITY. The rate of change of position in a given direction is velocity. Having magnitude and direction, velocity is a vector quantity. The term velocity should be used when referring to motion which is in a linear or in a curved direction.

SPEED. This is the term used in referring to irregular motion. If a runner is negotiating a winding cross-country course at a constant speed of one mile each five minutes, his velocity in any one direction is continually changing due to the constant change of direction (6, p. 114).

INERTIA. The tendency of a body to remain in its present state is inertia.

MASS. The quantitative measure of inertia is mass (7, p. 66). Mass is not identical to weight, but is the amount of matter in the body to which it is related. Wherever its location, a body has mass, but when acted upon by gravity it is possible to measure the force it exerts toward the center of the earth, which is its weight.

MOMENTUM. The momentum of an object is the product of its mass times its velocity (1, p. 33).

ACCELERATION. The rate at which a body changes velocity is acceleration. Constant acceleration indicates that the change of velocity is uniform. As velocity decreases, acceleration is negative. This reduction in velocity is known as deceleration. Constant velocity indicates zero acceleration.

WORK. Work equals the force times the distance through which the force acts.

POWER. Power equals force times velocity. Force varies directly with the square of the velocity, and power varies with the cube of the velocity (2, p. 99). Power is the rate at which work is done. The less time required to perform a given task, the more power necessary.

ENERGY. Energy is defined as the ability to perform work. Such ability exists in many forms. This ability to perform work may exist because particles are moving about rapidly or because there is an attraction force between them even though they are stationary. Energy which stems from the movement of particles is kinetic energy. Energy which exists because of attraction between molecules is called potential energy. Potential energy is inactive energy, or "stored" energy. Kinetic energy is active energy. Kinetic energy equals half the mass or weight divided by gravity of the body being moved, times the velocity of movement squared (2, p. 99).

TORQUE. When a force causes an object to rotate, torque has been exerted. Torque is equal to the product of the force times the perpendicular distance from the axis of rotation to the point where the force is applied. Torque is also known as "Force Moment" (6, p. 119).

MOMENT OF INERTIA. When considering rotatory motion, it is necessary to apply the concept of moment of inertia in place of mass, and consider the torque exerted instead of force. The moment of inertia of an object with respect to the axis of rotation is equal to the mass of the object times the square of its distance from the center of rotation (6, p. 119).

AIR RESISTANCE. In events such as the hammer and shot, air resistance is negligible and can be disregarded for all practical purposes. However, air resistance is of great importance in the discus and javelin events. Air resistance varies with the square of the velocity, and if speed is doubled the resistance becomes four times greater (6, p. 123)

LAW OF CONSERVATION OF MOMENTUM. This law states that when two or more objects collide with each other, momentum is conserved. The total momentum after the impact equals the total momentum prior to the impact (1, p. 197). Momentum is conserved in rotatory motion as it is in linear motion.

CENTRIPETAL AND CENTRIFUGAL FORCE. In the hammer and discus events, during the spin, turns, or whirl preparatory to throwing, it is necessary to pull inward on the hammer or discus to prevent the weight from flying outward. The faster the speed of rotation, the more the force necessary to hold it. This inward force is known as centripetal force. Centripetal force acts to pull the weight toward the center. At the instant centripetal force fails to act, the hammer or discus will fly off in a straight line tangential to its circular path. The force which tends to cause a rotating body to fly off at a tangent to its circle of movement or away from the center of rotation is known as centrifugal force. Centripetal force is the opposite of centrifugal force (6, p. 121).

The science of mechanics is based on three natural laws which were clearly recognized for the first time by Sir Isaac Newton (1642-1727). Newton's three laws of motion are:

(1) A body in a state of rest or uniform motion in a straight line will remain at rest or in motion at the same speed except insofar as it is compelled by forces to change that state. This is sometimes referred to as the "Law of Inertia."

(2) When a body is acted upon by force, the acceleration which results is proportional to the force, and inversely proportional to the mass. Thus in the case of an object of a certain weight, the greater the force applied to it, the greater the speed of the body. Given a certain force applied, the greater the weight of the object, the less the speed of its movement (1, p. 33).

(3) For every action there is an equal and opposite reaction.

The lever is a device used to gain mechanical advantage by producing turning motion about an axis. The lever consists of a fulcrum (the axis of rotation), a power arm (the perpendicular distance from the fulcrum to the point where force is applied), and a weight arm (the

perpendicular distance from the fulcrum to the weight upon which the force is acting). There are three types of levers, differentiated by the relative locations or force, fulcrum, and weight.

If the fulcrum (or axis) is positioned between the weight (resistance) and the force, it is a first class lever. This is the most efficient type of lever and may favor either speed or force, depending upon the relative length or the force and weight arms.

If the weight is between the fulcrum and the force, it is a second class lever. It always has a force arm which is longer than the weight arm, since the weight (or resistance) is located between the axis and point of application or force. The second class lever favors force, but at the expense of speed and range of motion. There are few second class levers in the human body.

In the third class lever, the force is between the fulcrum and weight. The third class lever favors speed and range of motion, but at the expense of force.

Most movement in the human body is produced by third class levers. The longer the force arm the greater is the amount of force about the axis. The shorter the force arm, the smaller is the moment of force but the more sudden is the action. The force arm of levers in the human body is relatively short, resulting in a rapid but relatively weak moment or force as a result of muscular contraction. If the objective is to exert tremendous force, the force arm should be as long as possible. If speed of movement is the objective, then the force arm should be relatively short.

Malcolm (5, p. 149) points out that once the body of the athlete leaves the ground and is in the air, the path of the center of gravity is already determined. If, while in the air, the athlete raises his arms, the center of gravity travels through the same path, but the movement of the arms has altered the balance of the body in the air. Now, instead of the center of gravity moving as is the case before contact is broken with the ground, the body automatically moves to make adjustment and the center of gravity continues on its same, or predetermined path. Thus while on the ground, the center of gravity moves in relation to the body, but while in the air, the body moves in relation to the center of gravity.

To exert force in order to cause acceleration, the athlete must remain in contact with the ground. Once contact is broken, no additional acceleration can occur. Thus a thrower who leaves the ground prior to the implement leaving his hand, cannot increase the momentum of his mass (which includes that of his body and the implement). Here, the application of Newton's third law of motion is clear in terms of action and reaction. The thrower who is off the ground and still attempting to exert force on the implement is in reality being pushed in the opposite direction (5, p. 153). While in contact with the ground and driving against the ground, the earth provides the reaction.

Housden (3) has pointed out that a discus thrower can increase his angular momentum only when he has contact with the ground, and suggests this experiment as proof: Stand with both feet on the ground and the right arm back behind the shoulder. Swing the arm round to the front and, as it comes to the front, raise the right foot and rise on the left toe. Rotation results. Repeat this action standing only on the left foot, and rotation again results. Then stand with only the ball of the left foot in contact with the ground, and repeat the movement with the right arm. No rotation is produced. This indicates that in order to produce angular momentum one must have some part of each foot on the ground, or the whole of one foot.

British Chief National Coach, Geoffrey Dyson, who is generally regarded as the world's leading authority on body mechanics as related to track and field athletics, is soon to produce a book treating this matter at length, and dealing in advanced concepts of the subject.

To date, the American coaches have displayed little interest in writing about the application of the various principles of mechanics to track and field athletics. It is modestly hoped that the above most superficial review of selected mechanical principles will serve to stimulate others to delve far more deeply into the science of mechanics and its application to track and field technique.

BIBLIOGRAPHY

1. Broer, Marion R., Efficiency of Human Movement, Philadelphia: W. B. Sanders Company, 1960

2. Bunn, John, Scientific Principles of Coaching. New York: Prentice-Hall, Inc., 1955

(continued on next page)

3. Housden, Fred, "Mechanics applied to discus throwing," Discobolus, 1959, no. 8, p. 5.

4. Metheny, Eleanor, Body Dynamics. New York: McGraw-Hill Book Company, Inc., 1951, p. 98

5. Meyer, H. A., Modern Athletics, by the Achilles Club, London: Oxford University Press, 1958.

6. Rasch, Philip J., and Burke, Roger K., Kinesiology and Applied Anatomy. Philadelphia: Lea and Febiger, 1959.

7. Sears, Francis Weston, and Zemansky, Mark W., College Physics, Cambridge: Addison-Wesley Publishing Company, 1953.

8. Weber, Robert L., White, Marsh W., and Manning, Kenneth V., College Physics. New York: McGraw-Hill Book Company, Inc., 1952, p. 110.

Ten Principles of Training

By Forbes Carlile M.Sc

Both coach and athlete should have a knowledge of the general principles of training the human organism.

Here follow the important principles which the writer considers are being employed in the best modern training methods.

1. The training load must be severe and must be applied frequently enough, and with sufficient intensity to cause the body to adapt maximally to a particular activity. (It is at the same time true that sustained all-out efforts in training or in races should be made only sparingly.)

2. Individuals react differently to the same training load. Always the most important consideration must be how the individual is responding to training, whether the athlete is carrying the physical load of training without strain or whether his body is slowly losing its capacity to adjust itself. Therefore, training will always be an individual problem.

No fixed training schedule should be followed rigidly. Blindly following any written schedule is unwise. Training must be tailored to suit the individual for best results. Of course, the best arrangement is for any sportsman to be under the constant supervision of a good, experienced coach.

There can be no one fixed training plan suitable for everybody. There are many factors which should be taken into account in drawing up a detailed schedule. Some of these factors are, the age of the athlete; time spent at everyday work and studies; the athlete's physical make-up; the time available for sleep and rest; the training facilities available, and so on.

3. Exercise involved in training is only one of a number of stresses acting on the athlete. All stresses must be considered when appraising the effect of training. For example, the wear-and-tear stress of daily travelling and manual labour must be overcome by the body.

The writer has discussed in detail the question of stress and physical response to training. This appears in three articles entitled "The Athlete and Adaptation to Stress" in the Physical Education Journal, published by the Australian Physical Education Association, University of Melbourne, December 1955.

Psychological factors are very important in training because emotional condition effects bodily function and can be a powerful stressing agent.

4. Too much stress for the individual causes strain and strain lowers performance level. The signs and symptoms of strain are many and varied. Some can be felt and thus appreciated by the athlete, others can be measured scientifically with relatively simple laboratory techniques. Some of these methods are dealt with in an article by the writer, "Athlete in the Laboratory," Sport Magazine, March 1958.

(continued on page 29)

The Tow Method--Training of the Future?

by Al Lawrence
(Olympic medal winner at 10,000meters; holder of two indoor records.)

During the past month, from Australia, came news of a revolutionary new method of training developed by Cecil "Chicks" Hensley. Hensley, a former champion marathon runner, released some of his findings in athletic circles in Sydney after three years of careful experimenting. The import of the new method caused much discussion among coaches and athletes alike; remarks from "fanatical" to "brilliant" were freely tossed about. However, most were content to sit back and adopt a "wait and see" attitude.

Hensley has quite often thrown a bombshell into athletic circles which has been called radical when first introduced, but after being tried, has proved to be quite sound. This was the man, who in the face of great opposition, introduced Junior (under 19 years) and Juvenile (under 16 years) cross country distance running in New South Wales in 1939. The cries of "burning them out" were soon forgotten when a brilliant series of athletes were produced from these ranks.

The new training method was released by Hensley when he was asked for an explanation of the rapid improvement of John Barret, his latest protege. Barret, who had been a mediocre 880 yards runner the previous season with a best time of 2:00.0 minutes, had suddenly began producing times of 1:52-plus consistently. Hensley explained that Barret was being towed in his training by car four times per week. This car-towing method, reported by Hensley, made it possible for his protege to run eight-second 100 yards in repetition without any undue strain or fatigue. The method evolved by Hensley is theoretically to develop and increase the capacity of the lungs, stretch all the muscles of a runner's legs, and lengthen the stride of the runner.

News of the story took me back to my own personal experiences with this method in the Australian summer of 1956. Long dissatisfied with the conventional methods of training, Hensley was restless to discover a more effective method of training middle distance and distance runners. Never content to be a follower, he finally came up with a theoretical scheme which he was keen to try, using me as his guinea pig. The idea of this method had first come to Hensley in 1925 from the early training of the great Finnish distance runner, Paavo Nurmi. Nurmi had attributed his beautiful flowing stride to his habit as a youth of hanging on to the sides of slow moving trains in Finland. Nurmi related how he was able to run for miles without fatigue and at the same time increase his stride while further strengthening his legs in the process. Hensley also told me of his own experiences, where as a boy sprinter he had improved his time for the 100 yards by one second after a year of holding on to the side of a tram car whenever he had the opportunity. Keen, though a little skeptical, I resolved I would try this method for a couple of months and see if it made any improvement in my running. This was the Olympic year, and while I would have cheerfully tried anything in an effort to make the Australian team, I did not want to prejudice what small chance I had by something that was as yet only a theory on paper.

Hensley had worked out a schedule of working me from 100 yards to 660 yards, commencing with twice a week workouts on the tow and gradually being increased to four times per week. The other days would be devoted to weight lifting to keep the development of the upper body in coordination with the development of the legs, plus running in salt water to stop any stiffness and soreness which might accumulate with the tremendous speeds I would be running in the future. Hensley had been busy designing a suitable tow bar that could be attached to his car at the correct height, and firm enough to pull my weight without losing its rigidness. He had also found a private ash road in a secluded location where we could begin our experiments without interruption. This ash road was quite suitable for wearing spikes and had a smooth, even surface.

As we had expected, the first few weeks revealed nothing in particular. I found that it was no effort to run repeat 100 yards in 9 seconds with only 110 yards recovery jogging after each.

Hensley proceeded carefully and had no wish to rush things along.

A doctor friend of his, when asked for his opinion of the method, said that he thought the longer stride achieved while being towed would stretch the biceps femoris muscle and the semitendinous muscle on the back of the thigh, and the three quadratus femoris muscles on the front of the thigh. It soon became apparent that my own stride was noticeably increasing in my races — the theory of an increased stride now becoming a fact. It is interesting to note that the Australian coach, Percy Cerutty is a great advocate of a long stride. In my case, stride increase had become definite in a couple of months.

After three weeks I was running 220 yard sprints in my tow training. In one session I recorded a 22-second effort, four 19-second efforts, and a blistering 17.5 clocking for my last tow. The only recovery period that was necessary was the 220 yards jog back to the starting point. After six weeks of the experiment I had my first track race of the Olympic season over 10,000 meters. My time of 29:50 was a new Australian record. Here was another indication that from a theoretical scheme the method had sound practical possibilities.

For the next month I jumped my training distances up to 660 yards. One of my sessions produced the following: One effort in 1:30, three efforts in 1:17, and the last effort a 1:10 clocking — through the first 440 in 48 seconds and coming home in 22 seconds. During the next month my 10,000 meters time was reduced to 29:20 and my 5000 meters to 14:01.8. Six weeks before the Games I stopped the training so as not to risk an injury so close to the big competition. In the Games I further improved my 10,000 meters time to 28:53.6. Here at last was a definite indication that Hensley was on the right track with his new method. His next task was to try and work out a training formula that could be applied to every distance runner. With this thought in mind he decided to introduce two young juniors to the new method. John Lawler and Denis Moore, who were working under my supervision, where chosen as the new "guinea pigs". Moore was the first to show sensational improvement when he recorded a 4:11 mile and an 8:50.8 two miles in little under a year. Lawler took another year before he showed the same improvement to record 1:53.4 for the 880 yards, 4:10.8 for the mile and 9:09 for the two miles.

A serious leg injury stopped me from further experimenting with the method during the next year, and shortly afterwards I left Australia to come to the United States. In the meantime, Hensley has been privately continuing his work with selected new pupils. He believes that another three or four years work will be needed before he can begin to evaluate the worth of his method. However, patience is something that comes easily to Hensley, as an athlete he did not show top form until he had reached the age of thirty-five and then was one of Australia's leading marathon runners for another six years before he retired from active competition.

Hensley believes that the only way to reach the top is to pioneer a new method of training rather than blindly follow the methods of current champions. In a recent statement regarding the tow method of training, Hensley said, "From careful experiments over the past three years I am convinced that this method has great possibilities. There is still a lot of work to be done," he added, "and much knowledge to be gained before I can fully understand the implications of the tow method. It has been clearly established that a runner's stride is increased substantially; and the faster running makes the athlete breathe more heavily, and thereby increasing his lung development." Hensley went on to further say, "The psychological benefits cannot be underestimated either. A runner knows that he can travel faster than any human being alive in his workouts without feeling any undue strain or fatigue and has now a method whereby he can accomplish great speeds without the tearing down of his body."

Only time will tell the worth of this ultra-revolutionary method, and while the Australian athletic world sits and wonders, Hensley is quietly continuing his work.

Training and Technique of Soviet Hop-Step-Jumpers

By Ruddi Toomsalu

Among the coaches there still exists an opinion that hop, step, and jumping is not an appropriate event for youngsters. But at the same time they realize that the preparation of a highly qualified athlete begins during his teen age. This is particularly true in those events where the acquisition of complicated technique is possible only after years of hard work. The coaches of the USSR are aware of this point of view, and together with training for all-round physical condition, the special exercises of hop, step, and jumping have an important position in the training program of youngsters. Special stress is placed upon exercise of the muscle groups that have a direct relationship to hop, step, and jumping; including back, stomach, hip joint, knee, foot, and particularly the muscles of the ankle joints.

Developing and strengthening of those muscles in the gymnasium should precede the actual learning of the jumping technique. The most important exercises are various kinds of jumping such as: (1) stand with feet together without bending the knees and jumping over medicine balls that are placed one meter or more apart, (2) the same kind of jumping on one foot, (3) jumping on both feet over low hurdles, pulling the knees against the chest, (4) repeated "step" jumps whereby the leading leg with bent knee is pulled high up, alternating the jumping off one foot and then the other, (5) standing hop, step, and jumping, (6) standing triple and quintuple jumps with both feet, and then with three preceding steps, (7) with three or five preceding steps, jumping successively from the floor on to a higher box, and then on to an even higher table, and finally over an even higher high jumping bar.

All of these jumping exercises should be performed on a soft surface, such as gym-mats, sawdust or rubber track, and with relaxed muscles. Sometimes it is advisable to organize a jumping contest between the boys using the above named jumping exercises.

From the very beginning one should stress the movements of an "active" landing, involving an "active down-pressing" of the leading foot. In learning the technique of the "hop", it is necessary to give attention to a delayed interchange of the feet in the air. From the standpoint of body balance, it would be most beneficial if the changing of the position of the feet were performed just before the landing after the "hop", as such a delay is helpful for an "active" landing. At the end of the flight of the "step" one should make a swing-up with the leading knee, and at the same moment both hands should be brought backwards, after which the landing is made with a quick rowing-like motion. Thereafter the hands are brought forward and upward, with a forced movement, thus helping to prolong the length of the "jump."

Inasmuch as the year-round training program of the best hop, step, and jumpers involves (a) general exercises, mostly intended for developing and then strengthening, (b) speed exercises, mainly sprinting, (c) exercises for developing jumping capacity, it is interesting to know how much time the Soviet athletes are devoting to these items. V. Baryshev, whose pupil O. Ryakhovskiy has made him world famous, has collected the following data ("Light Athletics of the USSR," No. 11, 1959).

In the personal training diaries of O. Ryakhovskiy (16.59 m), K. Tsigankov (16.19 m), Y. Chen (16.00 m), and V. Kobelev (16.01 m) it is clearly seen that in 1958 all of them have increased their emphasis on strength exercises at the expense of other items in their training programs. For example, in 1956 Ryakhovskiy utilized 41 hours from group (a) total training hours of 161 hours to the use of weight exercises. This indicates a ratio of 41 to 120, in the use of weight exercises. In 1958 this proportion was 81 to 106. For Tsigankov these proportions were 42 to 118 in 1956 and 71 to 154 in 1958. For Kobelev the ratio in 1956 was 26 to 122, and in 1958 Kobelev increased his ratio in the use of weight training to proportions of 43 to 117. This means that the strength exercises are occupying about 40 to 50 per cent of the total training, and that the efficiency of the take-off and proper landing in the "hop" and "step" are fully dependent upon muscular strength.

By observing actual jumps and jumping exercises, one might see a wide variation between them. L. Shcherbakov (16.46 m), V. Kreer (16.46 m), and O. Ryakhovskiy are spending 40 to 46 per cent of the total training time on jumping, while the percentage of K. Tsigankov and Y. Chen is only 20 to 30 per cent.

For a better understanding of the preliminary training of the Soviet hop, step, and jumpers, let us examine the training program of V. Kreer in 1956, the year when he won the bronze medal in Melbourne by doing 16.02 m.

January. (The outdoors competitive season generally starts at the beginning of May).

1/9/56. Morning: General exercises; jumping up and down on both feet 100 times, jumping from foot to foot 100 times; jumping on one foot 20 times.

Afternoon: In stadium. (1) Five exercises with the shot, repeated four times, (2) 500 m running and general exercises, (3) 2 x 60 m with short but fast strides, (4) 60 m relaxed running with fast long strides, (5) 2 x 100 m acceleration runs, (6) 4 x 75 m of "hops," (7) 3 x 100 m of "steps," (8) 260 m with many successive jumps, (9) 50 m "frog" jumping, (10) 260 m of "steps," including 97 "steps," and finally (11) 500 m running.

1/10/56. Rest in morning. General exercises in afternoon.

1/11/56. Morning: General exercises; jumping on two feet 100 times; jumping from foot to foot 100 times; jumping on one foot 20 times.

Afternoon: (1) 500 m running; general exercises, (2) 6 x 50 m acceleration runs, (3) standing hop, step, and jumping eight times (approximately 8.50 m), (4) hop, step, and jumping on two feet four times, (5) hop, step, and jumping on one foot three times, (6) 400 m covered with many successive jumps, (7) 2 x 10 sit ups, (8) strength exercises with a 32 kg. dumbell, 2 x 10 repetitions, (9) hop, step, and jumping two times, (10) throwing 32 kg. dumbells 3 x 4 series, (11) swinging dumbell on the right side (like hammer throwing) eight times, (12) 400 m covered with many successive jumps, (13) 250 m running, (14) hop, step, and jumping with dumbells in hands, two series.

1/12/56. Morning: General exercises; jumping on two feet 100 times; jumping on one foot 20 times; jumping from foot to foot 100 times.

Afternoon: (1) 1000 m run, general exercises, (2) weight lifting with barbell. Two arms snatch, 60 kg., 2 x 3 repetitions. 65 kg. twice; 60 kg. once; 70 kg. two times; clean and jerk, 75 kg., three times, (3) jumps with a 32 kg. dumbell, 50 and then 40 times, (4) ten sit ups, (5) standing shot put, eight times, (6) throwing the shot overhead, backwards, six times.

1/13/56. Rest.

1/14/56. Morning: General exercises; jumping on two feet 100 times; jumping from foot to foot 100 times.

Afternoon: In stadium. (1) 1000 m run. General exercises; 50 m running with short but fast strides, (2) 3 x 100 m acceleration runs, (3) six starts, (4) 5 x 80 m performing "hops." (5) 5 x 100 m performing "steps," (6) 200 m covered with many successive jumps. (7) 800 m run.

1/15/56. Morning: (1) general exercises, (2) weight lifting with barbells, two hands press using 60 kg. once; snatch, 60 kg four times; snatch, 65 kg. twice, 70 kg. once; clean and jerk, 70 kg. once, 75 kg. once, (3) jumps with a 32 kg. dumbell, 43 and then 41 times, (4) throwing the dumbell like the hammer 12 times, (5) shot putting nine times, (6) "sit ups," ten times and then eight times, (7) exercises for back muscles with dumbells, ten times.

In April, 1956, his training program was as follows:

Sunday. Morning: general exercises.

Afternoon: Strolling in the woods for 5 km (with easy 100 m runs and jumping from foot to foot, standing hop, step, and jumping three times in snow, enroute).

Monday. Morning: (1) general exercises, (2) stone throwing, three times, (3) jumping up and down on both feet, 20 times, (4) walking to stadium, 3 hours, (5) throwing stones, three exercises, six series.

Tuesday. Morning: general exercises.

Afternoon: (1) 1000 m run, general exercises, (2) 2 x 60 m sprints, lifting knees high, (3) 3 x 60 m with a stride where lower leg swings forward, (4) 2 x 100 m sprints. 100 m acceleration

run, (5) 10 x execution of "hop" with eleven m approach run. Best "hop" 5 m., (6) Execution of "hop" and "step" into a sand pit, with an approach run of 11 m, repeated ten times...5 m plus 4.30 m equals 9.30 m., (7) 3 sprints of 60, 100, and 80 m, using high knee lift, (8) 359 m with many successive jumps enroute, (9) 3 stone throwing exercises, repeated 6 times.

Wednesday. (1) 1500 m run, general exercises, (2) shot putting, (3) 3 x 60 m with short, fast strides, (4) 3 x 60 m with strides where the lower leg swings forward, (5) 9 x 25-30 m sprint starts. 2 x 100 m in 12.0 and 11.9 seconds, from sprint start position. 200 m in 25.0., (6) 100, 100, and 150 m sprints using high knee action, (7) 500 m slow running.

Thursday. Morning: five stone throwing exercises, repeated six times. Jumping from one foot and then the other, 50 times.

Friday. Morning: five stone throwing exercises, repeated six times, jumping from one foot and then the other, repeated 50 times.

Afternoon: In stadium, (1) 1500 m run, general exercises, (2) 4 x 100 m using short, fast strides, (3) 2 x 75 m, swinging lower leg forward, (4) 6 "hops" with an approach run of 27.50 m, landing in sandpit, (5) 6 hop, step, and jumps of 14.70 m, using an approach run of 15.50 m, (6) 5 "steps" from approach runs of 70 m, (7) 6 hops with an approach run of 7 m., (8) 2 x 130 m sprints with high knee lift, (9) sprint 100m and 200m, (10) 1000 m slow running.

Saturday. (1) 1500 m slow run, general exercises, 300 m acceleration run, (2) 3 x 100 m with short, fast strides, (3) 2 x 80 m relaxed run with fast but long strides, (4) 8 times over 4 low hurdles, (5) 2 x 150 m acceleration runs, (6) 8 "hops" with an approach run, landing in sandpit, (7) performing "step." 3 x 100 m sprints.

Sunday. 30 minutes of basketball

Which is the most desirable and profitable proportion of the lengths or distances of the "hop," "step," and "jump"? There are no general suggestions! These relative lengths are dependent upon the nature of the individual difference and ability of the athlete himself! When ex-world recordholder M. Oda (Japan) did 15.58, he "hopped" 6.42 m, "stepped" 3.41 m, and "jumped" 5.74.5 m. Later Oda suggested that his "hop" was too long and prevented the execution of an effective "step." Later the Japanese jumpers used a proportion of 3:2:3.

Then came L. Shcherbakov with his new world record of 6.07 m plus 4.97 m plus 5.19 m (16.23 total), with a mathematical proportion of $3\frac{1}{4}$: $2\frac{1}{4}$: $2\frac{1}{2}$. Then O. Ryakhovskiy did 6.46 m hop, 4.97 m step, 5.16 jump, total 16.59. In the meantime da Silva (Brazil) in 1955 did 6.28 hop, 4.95 step, 5.33 jump, total 16.56.

It is interesting to note that all of the Soviet jumpers are comparatively slow in the 100 m sprint. Conversely, the Japanese jumpers Nambu (15.72) and M. Oda (15.58) did 10.5 and 10.7 respectively for 100 m. But as we observe from the above training of Kreer, all of the Soviet jumpers have fully utilized the winter season for preparation, and through years of hard training have developed for themselves very strong and springy legs. It seems, therefore, that otherwise it is impossible to get results over 16 m.

Next came the Polish jumper J. Schmidt, who has run 100 m in 10.7. Schmidt became European champion, and his best result, 16.43 was made by 5.30 m hop, 5.20 m step, and 5.80 m jump! While not possessing as strong legs as the Soviet jumpers, Schmidt attempts to conserve his great forward momentum as long as possible, and therefore his single jumps are comparatively flat. Thus Schmidt's style is called "natural," or "running-jumping."

This does not mean that strong legs are now obsolete and should be thrown into the junk yard. Far from it! Last year a jumper appeared on the scene who ran 100 m in 10.7 and who broad jumped 7.7 m in 1956. His previous best in the hop, step, and jump was 15.73 in 1957. This man was Oleg Fyedoseyev, and he established a new world record of 16.07 m with a 6.49 m hop, 4.81 m step, and 5.40 m jump! Fyedoseyev proved that only jumping ability separately or only running ability separately do not make a champion... but rather both speed and jumping ability play an important role in getting height and maintaining momentum for the final "jump!"

The technique of world recordholder, Oleg Fyedoseyev. His height is 183 cm., and his weight is 80 kg. In 1959 while preparing for the outdoor season, he established an indoor record of 15.98.

The approach run is gradually increased in attaining his maximum speed at the instant of

take-off. His energetic take-off is accomplished with the stronger foot, and is accompanied with a powerful upwards action of the hands (Fig. 1-2). During the flight (Fig. 3-6), one should remember that the "walk-in-the-air" (interchanging of the feet) should not begin until after the jumper is well on his flight (Fig. 4), and after that the remaining distance of the flight is covered by a "step-position" (Fig. 5). Now the take-off foot (fight foot) is landing actively with a rowing-like motion, by which the heel touches the ground first, and then rolls over to the sole of the foot (Fig. 7). It is a serious fault when, at this moment, the lower part of the leg swings too far forward, since this would cause the forward momentum of the body to be checked or decreased. But swinging the lower part of the leg and foot forward is a common fault in case the jumper does not possess strong foot and leg muscles.

For maintaining a steadily balanced position of the body, Fyedoseyev pulls his hands sidewards and backwards (Fig. 5-7). In addition to this, such a position of the hands helps to create a more powerful upward thrust of them at the moment of take-off for the "step" (Fig. 8).

To lengthen the flight of the "step', one should lift the knee of the leading leg. This is also done to cover the flight in a "step-position" (Fig. 9). It is easier tc maintain such a position when the arms are again brought sidewards and backwards (Fig. 10). The landing, heel first, is performed by an active stamp on the ground (Fig. 11). Here too, frequently, a mistake is made when the lower leg and foot swings too far forward.

As the momentum of the jumper is significantly decreased, he should vigorously strain to obtain height for the "jump." The "jump" is executed like a knee-tuck type broad jump (Fig. 13-17).

As S. Kuznetsov, the coach of Fyedoseyev has said, his technique is far from perfect. This is particularly noticeablein the phase of the take-off for the "jump," where Fyedoseyev does not possess a well-balanced position. For this reason, his body leans too far forward at the time of the flight, thus causing his feet to land prematurely (Fig. 17).

BIOGRAPHY

Above story by Ruddi Toomsalu, Tallinn, Estonia. Toomsalu is a former member of the New York Athletic Club, and is now Professor of Physical Education and Track Coach at the Technical College in Tallinn, Estonia.

Pictures taken from LIGHT ATHLETICS OF THE USSR, No. 8, 1959.

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10 PRINCIPLES (continued from page 23)

5. Recuperation periods are essential both during a single training session, and throughout the year. Rest, with consequent physical and mental relaxation, must be carefully blended with doses of exercise. A rhythmical cycle of exercise and recuperation should be established both within individual training items and week by week.

6. Training is specific. Although there is a certain amount of carry-over, as a rule the best training for a particular sport is not of much use for another. Thus swimming training will not help the high jumper nor will fencing help the long-distance runner. Carrying this concept further, we find that within a particular sport, training is specific. For instance, the best training for a sprint swimmer or runner will not suit even the 400 meters performer. Every event requires special preparation.

7. Strengthening and flexibility exercises are very beneficial. These two types of training carries out mainly in the off-season should be carefully designed and directed at specific groups of muscles and joints.

Looseness and a high degree of flexibility means free-flowing movement.

It is now clearly established that great strength, brought about by resistance exercises (e.g. weight training) improves performance in many fields. Scientifically designed weight training, with appropriate stretching exercises, does not slow down the sportsman or cause a "muscle-bound" condition.

8. Interval training is the most important individual training item in the modern training

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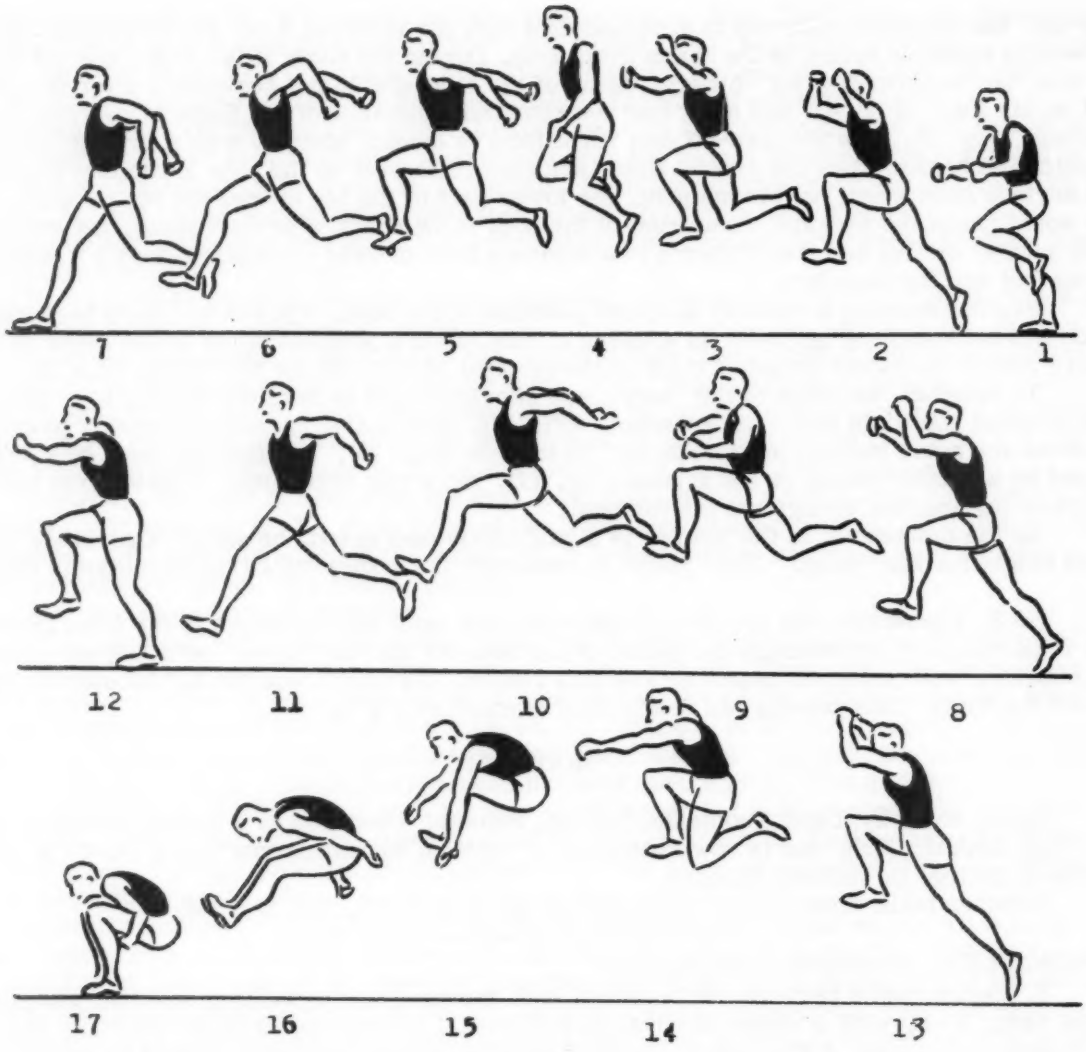


10 PRINCIPLES (continued from page 29)
schedule.

This consists fundamentally of rhythmically carrying out an activity from 30 seconds to one minute at fairly intense effort (but not all-out). Each exercise period is followed by 10 seconds to two minutes of slow, recuperative activity.

9. Efforts at the athlete's race distance play an important part in a training program. By repeatedly covering the race distance with relatively short recuperation periods between, the body is "grooved" to performing at that specific distance. The individual, by studying intermediate times learns how to judge an even pace, which is essential for best performance. These "efforts" are for the most part made at between 80 and 90 per cent of the all-out speed. All-out performances with maximum effort at the full race distance are seldom made more than once weekly.

10. Nutrition plays a major role in physical performance. The first requirement in diet is a good variety of foods with many as nearly as possible in their natural state. In addition, certain food substances (e.g. vitamin E) even when supplemented to many times normal requirements improve physical performance.

How They Train

by Fred Wilt

OTIS RAY NORTON, San Jose State College, Oakland Junior College, and Oakland (California) High School. Age 22.

BEST MARKS: 220 yards, 20.2 seconds, 200 meters, 20.6 (curve); 100 meters, 10.1 seconds (world record); 100 yards, 9.3 seconds (world record).

BORN September 22, 1937 at Tulsa, Oklahoma, 6 feet 2½ inches tall, 180 pounds, started racing in 1947 at 10 years of age.

WARMUP: (Identical for workout or competition). Jog 880 yards very slowly. Gymnastic exercises. 3 x 110 yards fast running, each faster than the previous one. 110 yards running concentrating upon lifting the knees high. Walk 110 yards after each 110 yards of running. 2 - 4 x 30 yards sprint starts, beginning slowly and increasing speed to fast start. Duration of warmup - 20 minutes.

PRE-COMPETETIVE (WINTER) SEASON TRAINING:

Monday: 10 x 110 yards. Walk 110 yards after each. Start with 15 seconds each 110 yards, and reduce the time by one second each month, until four weeks before competition. Following these 110 yards runs, run 440 yards, alternately sprinting 15 yards and jogging 15 yards.

Tuesday: Sprint starts. 2 x 20 yards. 2 x 30 yards. 2 x 40 yards. Then 5 x 220 yards. Walk 220 yards after each. Start at 32 seconds each, and reduce the time by two seconds each month until four weeks before competition. Finally, ten minutes of baton exchanging practice with relay team mates.

Wednesday: 5 x 55 yards. 5 x 110 yards. 5 x 55 yards. Walk an equal distance after each. The speed is identical to Monday, except that the 55 yards repetitions are slightly faster. Then finally 440 yards of alternately sprinting 15 yards and jogging 15 yards as on Monday.

Thursday: 20 minutes of baton exchanging practice with relay team mates. Then 3 x 300 yards at ¾ full speed, sprinting at the finish. Walk 300 yards after each. Gradually reduce the time (increase the speed) of the 300 yards runs each week.

Friday: 15 minutes of baton exchanging practice with team mates.

Saturday: 2 x 60 yards sprints. Walk for full recovery. Then 300 yards as on Thursday.

Sunday: Rest.

COMPETITIVE SEASON (SUMMER) TRAINING.

Monday: 2 x 300 yards as on Thursday (above).

Tuesday: Sprint starts. 2 x 20 yards. 2 x 30 yards. 2 x 40 yards. Walk an equal distance after each. Then 15 minutes of baton exchanging practice with relay team mates. Finally, 3 - 4 x 220 yards fast striding, but not timed. Walk 220 yards after each.

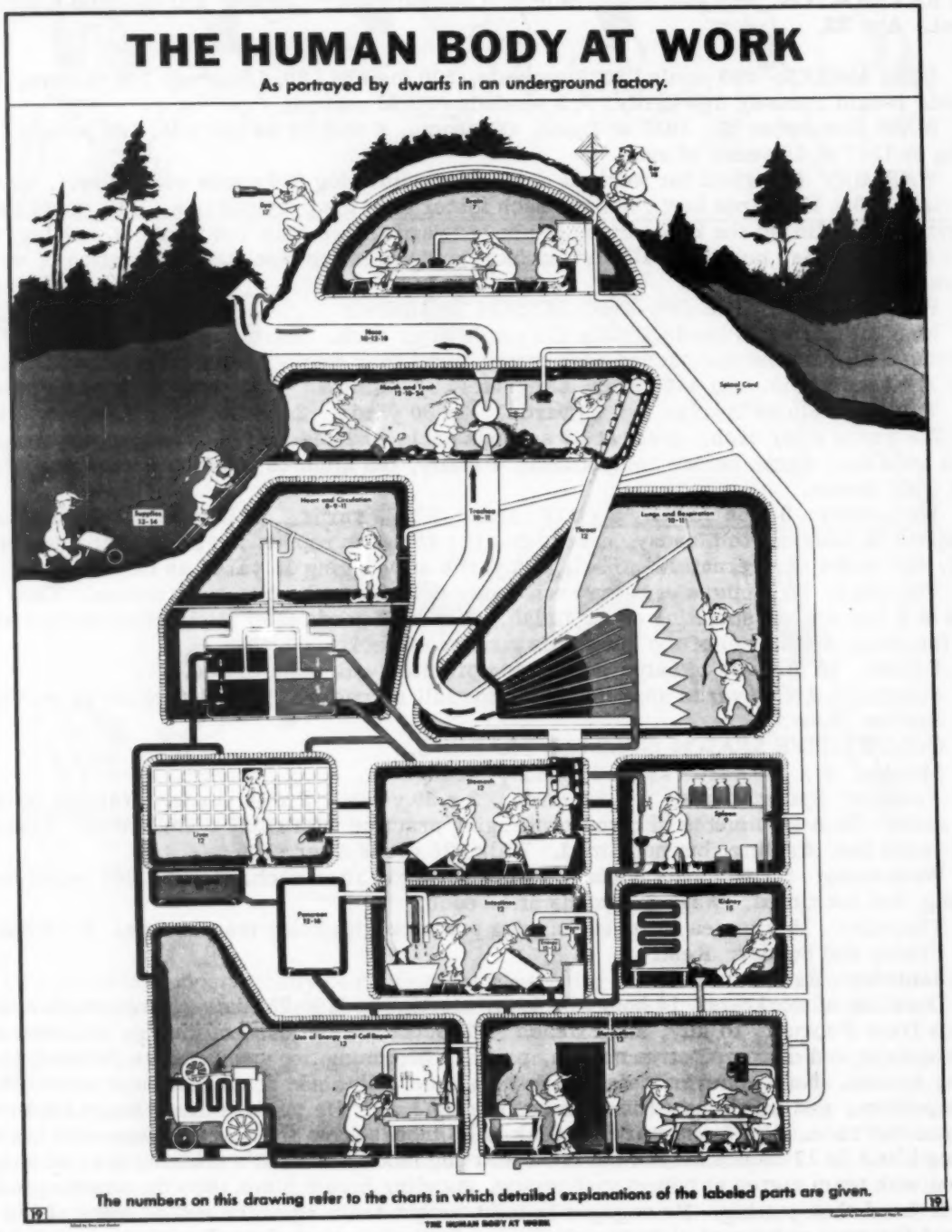
Wednesday: 2 x 60 yards sprints. Walk 60 yards after each. 1 - 2 x 300 yards fast striding, but not timed. Walk 300 yards after each.

Thursday: 15 minutes baton exchanging practice with relay team mates. 4 - 6 sprint starts.

Friday and Sunday: Rest.

Saturday: Race.

Duration of workouts: 1½ hours or less, starting at 3:00 PM daily. Competetive season extends from February to July, and extends until September in case of foreign athletic tours. Rests two months at end of competetive season, prior to beginning pre-competetive (Winter) training for coming season. Norton never trains more than once daily. He rests from one to two days prior to competition, and participated in 58 races during 1959. He prefers three hours between his final meal and the race. His front starting block is 16 inches from the starting line, and his rear starting block is 17 inches behind the front starting block. Norton's training also includes fun competition with team mates at hop-step-jumping, standing broad-jump, javelin throwing for accuracy, and left-hand shot-putting. He engages in light weight-training at the end of some of his workouts. Suffered fracture at base of right thumb playing football in High School, which never healed properly. Consequently, in crouch sprint start he uses curled hand with knuckles on ground. Is a student of physical education, and hopes to coach.



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